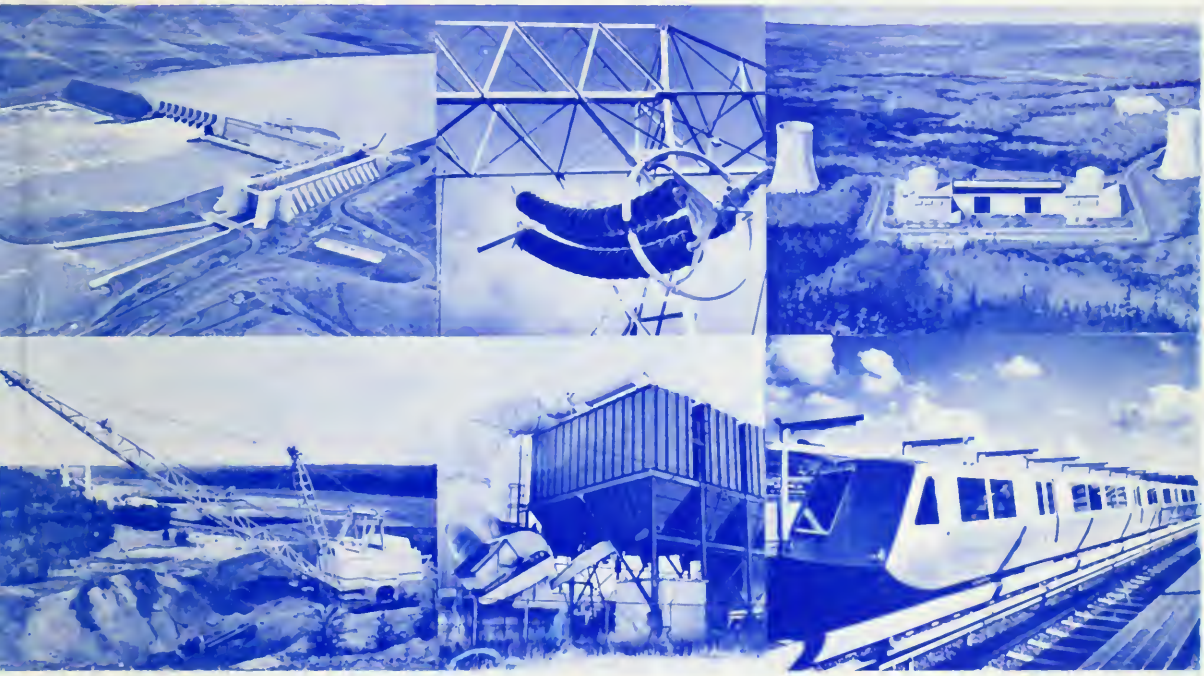
S
333.82
W32e
1976

WESTERN STATES ENERGY RESOURCE DEVELOPMENT UPDATE 1976

STATE DOCUMENTS

NOV 15 1976



Western Interstate Nuclear Board
P O BOX 15038 • LAKEWOOD COLORADO 80215 • (303) 238-8383

SEPTEMBER 1976

NOV 17 '86 L6 77

MONTANA STATE LIBRARY
S 333.82 W33o c.1 Wilkinson
Western States energy resource developme

3 0864 00024776 0

WESTERN STATES ENERGY RESOURCE DEVELOPMENT

UPDATE 1976

Prepared for
WESTERN INTERSTATE NUCLEAR BOARD

by
Lawrence E. Wilkinson, Consulting Engineer

SEPTEMBER 1976

WESTERN INTERSTATE NUCLEAR BOARD
P.O. Box 15038
Lakewood, Colorado 80215

PREFACE

The Western Interstate Nuclear Board (WINB) is an outgrowth of the 1967 Western Governors' Conference. The Board is chartered to foster interstate cooperation in resolving nuclear and other energy-related problems in the twelve-state Western Region through various cooperative research, planning, and informational efforts. WINB has conducted programs on a variety of issues that affect member states, including transportation of nuclear materials, power plant siting, uranium enrichment, radioactive waste management, mutual radiological assistance, etc.

In the past five years, WINB has been increasingly called upon to help determine how nuclear projects can best fit into the energy developments unfolding in the West. To assist in these determinations, an Energy Committee has been created to examine the balance of the energy developments as well as potential of the nuclear projects. The WINB Energy Committee commissioned a study by an independent consultant, Lawrence E. Wilkinson, in 1973 and again in 1976.

The first study resulted in a January 1974 publication entitled Energy Resource Developments in the West. This report is an update of the 1974 report and contains schedules for new plants as of June 30, 1976. The report shows that the West can become self-sufficient with respect to energy only through efforts towards energy conservation and deployment of a considerable amount of coal resources in addition to the scheduled nuclear projects.

This document is submitted to the Governors, state government officials and other regional leaders in the hope that it will be helpful in the planning and decision-making processes of the public and private sectors.

It is not the intent of this report to take a position on energy policy, however, WINB recognizes that realistic natural gas pricing and conservation are important determinants towards developing the necessary reserves for meeting future needs in the West.

Donald C Gilbert

Don Gilbert, Chairman
Committee on Energy
Western Interstate Nuclear Board

July 1, 1976

ACKNOWLEDGMENT

The author is indebted to the Energy Committee of the Western Interstate Nuclear Board for its guidance and critical comments and especially for sharing its observations on how the energy resource development opportunities vary within the various sub-regions of the West. The members that make up the energy committee include:

Chairman: *Donald C. Gilbert, Director, Arizona Atomic Energy Commission

*Dr. John Bellamy
University of Wyoming

*Noel Clark, Chairman, Nevada Public Service Commission

Kenneth Geiser, Chairman, Arizona Atomic Energy Commission

*T.W. Ten Eyck, Rio Blanco Oil Shale Project

Gene P. Rutledge, State Energy Office of Alaska, formerly with State of Idaho

Appreciation is also expressed here of the efforts by the WINB staff in publishing this report.

* State delegate to WINB

Table of Contents

		Page
1.0	Introduction	1
2.0	Summary and Conclusions	2
3.0	Energy Demands in the West, 1950-2000	4
4.0	Energy Production in the West, 1970-1985	16
5.0	Energy Resources Under Development in Region, 1976-1985	32
	5.1 Oil	32
	5.2 Natural Gas	34
	5.3 Hydroelectric	38
	5.4 Coal	42
	5.5 Uranium	47
	5.6 Geothermal	52
	5.7 Developing Technologies	53
6.0	Factors Impacting on Consumption	53
	6.1 Conservation	53
	6.2 Economy	53
7.0	Factors Impacting on Production	55
8.0	Contingency Planning and Conservation Efforts in Member States	56
9.0	Actions Open to Member States	58
10.0	Appendix A Conversion Factors	59
	Appendix B WGC 1974 Statement on Western Regional Energy Policy	60
	Appendix C Glossary	63

LIST OF FIGURES

		Page
3-1	Historic U.S. Energy Consumption Patterns	4
3-2	Total Energy Use and Total Electrical Demand Projected for Western United States (Updated)	6
3-3	Projected Relationship of Energy Demands and Future Employment	7
3-4	Population in Western States	8
3-5	Energy Consumption in Western States - 1974	11
3-6	Effect of 1973-74 Oil Embargo on Electrical Load Growth	13
3-7	Seasonal Peaking of Electrical Sales in WINB Region and in States with Highest Demands - 1974	14
3-8	Seasonal Peaking Of Electrical Sales in Balance of WINB Member States - 1974	15
4-1	Energy Production in Western States - 1974	17
4-2	Net Energy Balances of Western States - 1974	18
4-3	Energy Forms Involved in Production and Consumption in Western States - 1974	20
4-4	Use of Bituminous Coal and Lignite in WINB Member States	21
4-5	Scheduled Coal-Fired Plant Locations in WINB Member States	22
4-6	Locations of Nuclear Powered Electrical Generation Facilities on the Western Loop	27
4-7	Trojan Nuclear Plant in Operation near Portland, Oregon	28
4-8	Rancho Seco Nuclear Plant No. 1 near Sacramento, Calif.	28
4-9	Growth Patterns of Coal-Fired and Nuclear Thermal-Electric Generation in WINB Region	29
4-10	Electrical Generation Resource Mix as of December 31, 1974	30
4-11	Expected Electrical Generation Resource Mix as of December 31, 1985	30
4-12	Trends in Electrical Generation Capacities in Western States	31
5-1	Major Offshore Oil and Natural Gas Exploration Areas in Alaska	33

LIST OF FIGURES Cont.

		Page
5-2	Placement of Shale Oil Syncrude and Syngas into Commercial	35
5-3	Location of Federal Leased Oil Shale Tracts in Green River Basin	36
5-4	Proposed Routing of Prudhoe Bay Gas Delivery Systems	37
5-5	Projected Marketed Natural Gas Production from WINB Member States	38
5-6	Predicted Non-Associated Natural Gas Availability at Three Wellhead Price Scenarios	39
5-7	Placement of Annual Reserve Additions of Natural Gas	41
5-8	Grand Coulee Project on the Columbia River in Northern Washington	43
5-9	Three Units of the Bridger Coal-fired Plant near Rock Springs, Wyoming	43
5-10	Coal Production Growth in the U.S. and in the West	44
5-11	Historic and Projected Coal Production in the Western States	45
5-12	Routing of Existing, Proposed and Planned Coal-Slurry Pipelines	46
5-13	Surface mining and Soil Reclamation Activity near Glenrock, Wyoming	47
5-14	Nuclear Based Electrical Generation Growth in the U.S. and in the West	48
5-15	Principal Uranium Producing Areas for 87 percent of U.S. Production and Processing Plants	51
5-16	Potential Geothermal Fields in the West with Activities noted	52
5-17	Solar Insolation Contours in the Southwest	54

LIST OF TABLES

		Page
3-1	1974 Fossil Fuel Consumption and Production in the Western States	10
3-2	Electrical Energy Production and Consumption in Western States	12
4-1	Existing Coal-Fired Electrical Generation Plants in the West	23
4-2	Coal-Fired Electrical Generation Plants Scheduled or Under Construction in the WINB Member States	25
4-3	Existing and Scheduled Nuclear Power Plants in the WINB Member States	26
5-1	Hydroelectric Resource Additions to Region (1976-1985)	40
5-2	Potential Coal-Slurry Pipelines Originating in WINB Member States	49
5-3	Uranium Ore Processing Plants in the U.S.A.	49
5-4	Historical Estimates of Uranium Proven Reserves	50
5-5	Potential Resource Estimates for Uranium within the U.S.A.	50
5-6	Distribution of 1974 Exploratory Drilling for Uranium in the U.S.A.	51
8-1	Energy Conservation Measures to be Considered in State/Federal Conservation Program	57

1.0 Introduction

The year 1974 was the end of the Arab oil embargo and the beginning of higher energy prices for all fuel commodities. It is also the latest year for which energy consumption and production data is complete. This report is an analysis of the energy use patterns of each western state for 1974. The report is also a study of the planning by energy industries and utilities up to June 30, 1976. Included are descriptions of efforts by the federal and state governments to help the nation achieve energy independence.

Particular emphasis is placed on the electrical energy consumption and production of the individual states and how the member states are expecting to continue to have sufficient energy to keep their citizens employed, healthy and safe. The balance between coal-fired and nuclear power plants has been of special interest to WINB, thus, it is treated in special depth. Not included in the energy balances is the energy invested in products shipped into the region or the energy in the uranium shipped out of the region.

The energy consumption patterns are examined over a long period (1950-2000). Although there is some uncertainty about the next 25 years, the creativity and the industriousness of the American people is not expected to vary a great deal from their historic patterns. Where judgment was required in the report, the author has given greater weight to future needs based on historic patterns than to needs based on no-growth patterns, since this results in a more defensible estimate.

The expected energy production systems are only presented for the next ten years (1976-1986). Beyond ten years, the planning is too nebulous to be meaningful. Not all of the plants presented will be built. Some future loads may need to be met by alternate plans.

Due to the unsettled nature of the synthetic oil and gas industries, little attention is given to synthetic fuels. There is little doubt that a synthetic fuel industry could be built in the U.S. The only question is, when it should be built. When less expensive fuels are no longer available, may be soon enough. Meanwhile, government efforts described should be considered as technology development rather than a substitute for more intensive electrification.

The report attempts to support the goal of national energy independence. Where obstacles appear contrary to meeting that goal, they are mentioned in an effort to reduce institutional barriers to a very ambitious and worthwhile national goal.

2.0 Summary and Conclusions

The 1974 WINB Energy Study showed a collective annual energy deficit of 165 million BOE (Barrels of Oil Equivalent) for the Western States. This 1976 WINB Energy Study shows a collective deficit 53% greater (@ 252 million BOE). The data years for the above studies were 1971 and 1974 respectively. Even in 1974 it was too early to expect to see results of a conservation effort.

This 1976 WINB Energy Study should bring hope to those earnestly attempting to achieve national energy independence. It also identifies some factors that impede stability in the supply of various energy commodities.

The report shows that over $40 billion is scheduled to be invested in the West in the next ten years to explore, extract, refine, and transport energy commodities and another $68 billion is scheduled to build electrical generation and transmission facilities. Even with such an investment the West could still be importing energy if conservation efforts are not effected.

The report describes the needs and limits of conservation efforts. Because conservation can be accomplished sooner and with less expense than building new capacity, state and federal efforts are directed to implement new conservation programs. The electrical energy facilities already installed in the West could not be replaced by a like investment. New facilities will generally raise the average cost to the consumer. Energy conservation is intended to minimize the need for more expensive new generation facilities.

The report shows great disparity among the WINB member states with respect to population and energy resources. Collectively, however, the region is a good mix and was within 15% of being self-sufficient in 1974.

Growth in the nuclear sector has not kept pace with anticipations of three years ago. Most of the replacement plants have been coal-fired, very significantly raising the ratio of coal to nuclear plants. The shift is, in part, a result of the current unpredictability of electrical load growth.

Other than the coastal states, the region is moving strongly to coal-fired power plants. Good ventilation and easy access to coal fields and access to cooling water are the most likely reasons for these developments. Continued development in this region may depend on wet/dry cooling systems.

Alaska has the Trans-Alaska Pipeline (TAP) more than half complete with oil scheduled to flow into Valdez in the latter half of 1977. At the same time Alaska is pursuing activities towards building a new hydroelectric project to serve loads in the railbelt area which includes Anchorage, Fairbanks and perhaps the new capital city. The State of Alaska has endorsed a natural gas pipeline parallel to the TAP which would lead to conversion to LNG and transport to the California coast.

Oil and natural gas from Alaska appear to be barely sufficient to make up expected deficits in the Western States. Coal is available from Alaska also and may be exported to Pacific-rim nations if uses do not develop in the coastal states.

Small oil and gas-fired power plants are being retired as new larger coal-fired plants are being activated. One nuclear power plant is being retired in 1977. The plant was designed for both power and plutonium production. It was expensive to operate and not able to be licensed with current regulations.

Geothermal power continues to show promise but is the only developing technology that is expected to make significant contribution to electrical generation by 1985. Federal support continues to be needed to foster a strong geothermal effort.

Outer continental shelf leasing for exploration continues to be active in Alaska and will later be active along the lower coastal states. With onshore Alaskan oil sufficient to saturate West Coast markets, the need for high risk production has been questioned.

The synthetic fuels development from coal, tar sands and oil shale appears destined to proceed only through federal loan guarantees or other incentives, and mostly for energy independence rather than economy of operation.

Natural gas continues to be in high demand and faces the potential for longer and more frequent curtailments in many locations. Until the natural gas price situation is resolved, other promising energy sources will remain economically unattractive.

The last group of hydroelectric projects in the West (excluding Alaska) is nearing completion. Most will be used for peaking rather than being new primary energy sources.

The uranium industry is faced with an unprecedented demand for fuel for the next 30 years. New exploration efforts are proceding at a record pace.

Conservation continues to be the first step in ensuring the energy needs for future health, safety and prosperity in the West. Many industries have already made adjustments to conserve energy. Efforts are continuing to inform the public on how they can reduce their personal demands and how to keep their energy budgets trimmed. Until the limits of conservation are better known, forecasts of needed facilities will remain speculative.

3.0 Energy Demands in the West, 1950-2000

The Western Interstate Nuclear Board is comprised of representatives of the following states:

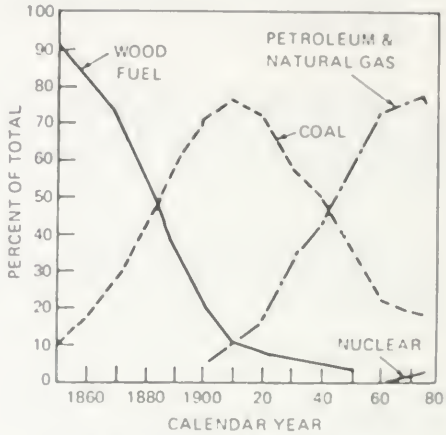
- Alaska
- Arizona
- California
- Colorado
- Idaho
- Montana
- Nevada
- New Mexico
- Oregon
- Utah
- Washington
- Wyoming

Collectively, the member states cover 49 percent of the territory in the U.S.A. and represent 17 percent of the population. Energy sources among the member states vary widely, although collectively the energy production and consumption is similar to the total nation.

The past five years have been particularly interesting with respect to energy demands in the U.S. During this five years the price of many fuel commodities has doubled and some have more than quadrupled. The first stimulus for the rapid price escalation was the embargo by the oil producing nations. After the embargo, oil import prices were quadrupled. Secondary effects, such as the doubling of steel prices, and other inflation effects has caused new power plants to be much more expensive than existing plants. Thus a rapid increase in the cost of electrical energy has ensued.

The net effect of the oil-based price spiral is expected to be the beginning of a national shift to an alternate energy base. Figure 3-1 illustrates interesting, similar shifts in the history of the U.S. The shift from wood to coal was needed to fuel the industrial revolution and then a shift to liquid fuels as oil and natural gas recovery techniques were perfected. Now, with the end of oil and gas resources within sight, a new dependence on uranium and a renewed dependence on coal is expected.

Both uranium and coal are readily convertible into electrical energy. Therefore, there is strong interest in the extent of electrification that can take place before oil and natural gas become exorbitantly expensive for electric generation. Just as it took several decades to shift from wood and coal, a shift from an oil economy to electric and other alternate energy forms may require several decades because of the investments and lead times required.



SOURCE HISTORICAL STATISTICS OF THE UNITED STATES BUREAU OF THE CENSUS U.S. BUREAU OF MINES 1974

Figure 3-1 **Historic U.S. Energy Consumption Patterns**

The higher prices for all energy sources have clearly outstripped the increases in wages during the same five-year period. As a consequence, fuel budgets have begun to erode the spendable income of most American families. Adjustments have been made in the habits of most families to ameliorate the impact. The historic expotential growth of energy demands appears to have been broken.

Among the first fuel commodities with which to relate higher imported crude oil prices are distillate fuel oils and gasoline. The potential for conservation of these two fuels may be relatively easy with lowered thermostats, more insulation and fewer vehicular miles. With prices of natural gas regulated, gas conservation appears to be controllable primarily by shortage. Natural gas service interruptions of over 100 days per year are common in the coastal states for industrial consumers.

Useage of electrical power is expected to continue to grow about 5 percent per year dispite sound conservation practices. The 5 percent rate, however, is slower than the historic rate of about 7 percent per year. Of the 5 percent, a portion is simply due to population growth.

Various forecasters have speculated on the expected growth rate of energy in total, and electrical energy demands in particular. Reflecting on more recent forecasts,[1,2,3] the pre-embargo growth rate published in the 1974 WINB Energy Study has been modified and presented again as Figure 3-2. The total energy demands are again 15.3% out of a forecast lower national energy consumption of 170 quads (170 x 10^{15} BTU's) by 2000 A.D. Even though the West has 17% of the nation's population it uses only 15.3% of the total energy. In the West, however, a greater portion is converted into electricity. The 50% conversion forecast in the 1974 WINB Energy Study, for 1990, has been retained and a 60% conversion has been forecast for the year 2000. Nationally, the electrical portion has been forecast,[4] by the year 2000 to be 53 percent ± 10 percent.

Results of the recent work done at the Electric Power Research Institute on the probable extent of electrification have been presented in Figure 3-2, also, and described as the "National Pattern." Although the upper end of the range may be too steep to recover before saturation occurs, the lower end of the range appears modest, indeed. In Congressional testimony[4], Dr. Starr suggests use of a mid-range number of about 53 percent for the year 2000. The largest uncertainty will be the extent to which transportation systems are electrified. Transportation systems currently account for 25 percent of the national energy consumption. If global oil sources near depletion by the year 2000, the 53 percent may be modest. If nationally, 53 percent is a good choice, then the 60 percent assumed herein for the West appears reasonable as plotted in Figure 3-2. The total energy demand in the West and in the nation will depend on national goals for economic welfare and civilian employment. The Bureau of Census is predicting a U.S. population of 263 million by the year 2000. With a 4% unemployment rate this would provide a workforce of 113 million. The Bureau of Economic Analysis is projecting a 20-year historic growth rate of 3.5% which would lead to a GNP of slightly over $2 trillion by the year 2000. It has been shown, many times, that the gross national product has a nearly linear relationship with energy consumption. To supply the above workforce with the energy needed to produce $2 trillion per year in goods will require about 170 quads, and is shown by Starr as the "historic growth" in Figure 3-3.

The "no growth" case would be to freeze the amount of energy available per worker to the 1973 rate. By so doing is to risk freezing societal growth at the same time. A "limited growth" position may be available but can be achieved by choice rather than by necessity for lack of energy availability.

The energy demand, and the fuels used vary considerably among the western states. The population spread is great also. To compare the relative consumption of energy among the western states, British Thermal Units (BTU's) and Barrels of Oil Equivalent (BOE) are used. A barrel of oil contains about 5.8 million BTU's and is a more tangible unit, BOE per capita, helps to characterize individual actions as contrasted with state totals. The energy content of oil and other fuels is presented in the Appendix.

The population used for the per capita calculations is shown in Figure 3-4. Note

---

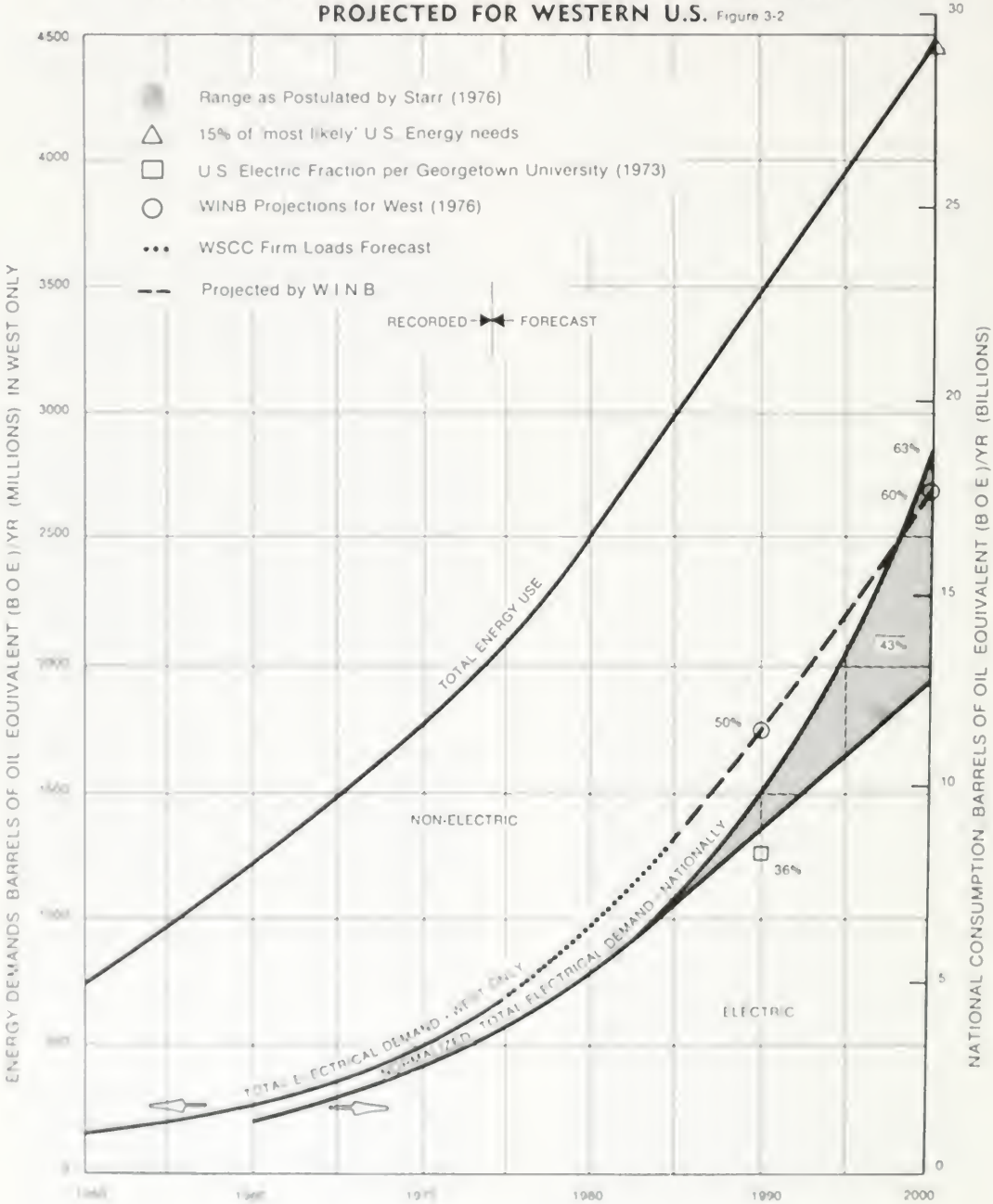
[1] "Long Range Projection of Power Loads and Resources for Thermal Planning-West Group Area 1976-1996" Pacific Northwest Utilities Conference Committee, April 16, 1976.

[2] "PUC Forecasts-G.O. 131 (1975-1984)" California Public Utilities Commission, 1976.

[3] "Impacts of Alternative Electric Supply Systems for California" Western Interstate Nuclear Board May 7, 1976.

[4] "Electricity Needs to the Year 2000 as Related to Employment, Income and Conservation," C. Starr to Subcommittee on Energy Research Development and Demonstration, House Committee on Science and Technology, February 26, 1976.

TOTAL ENERGY USE AND TOTAL ELECTRICAL DEMAND PROJECTED FOR WESTERN U.S. Figure 3-2



Projected Relationship of Energy Demands and Future Employment Levels

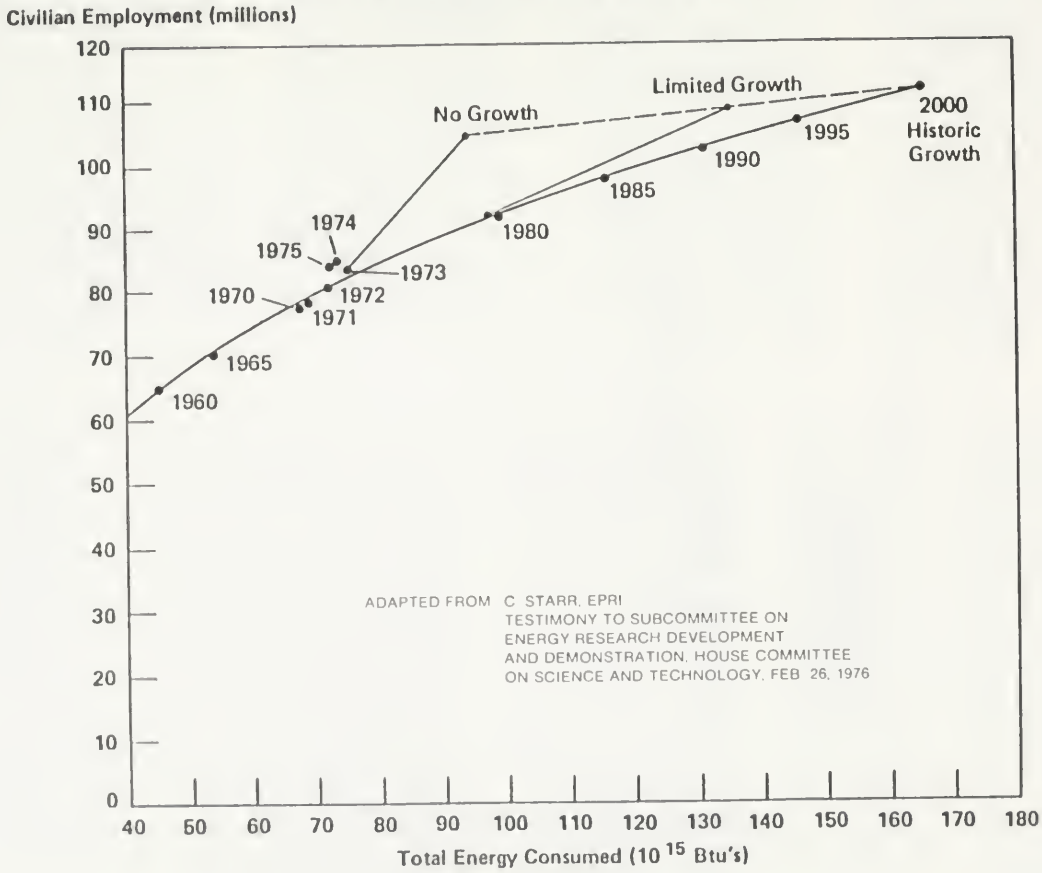
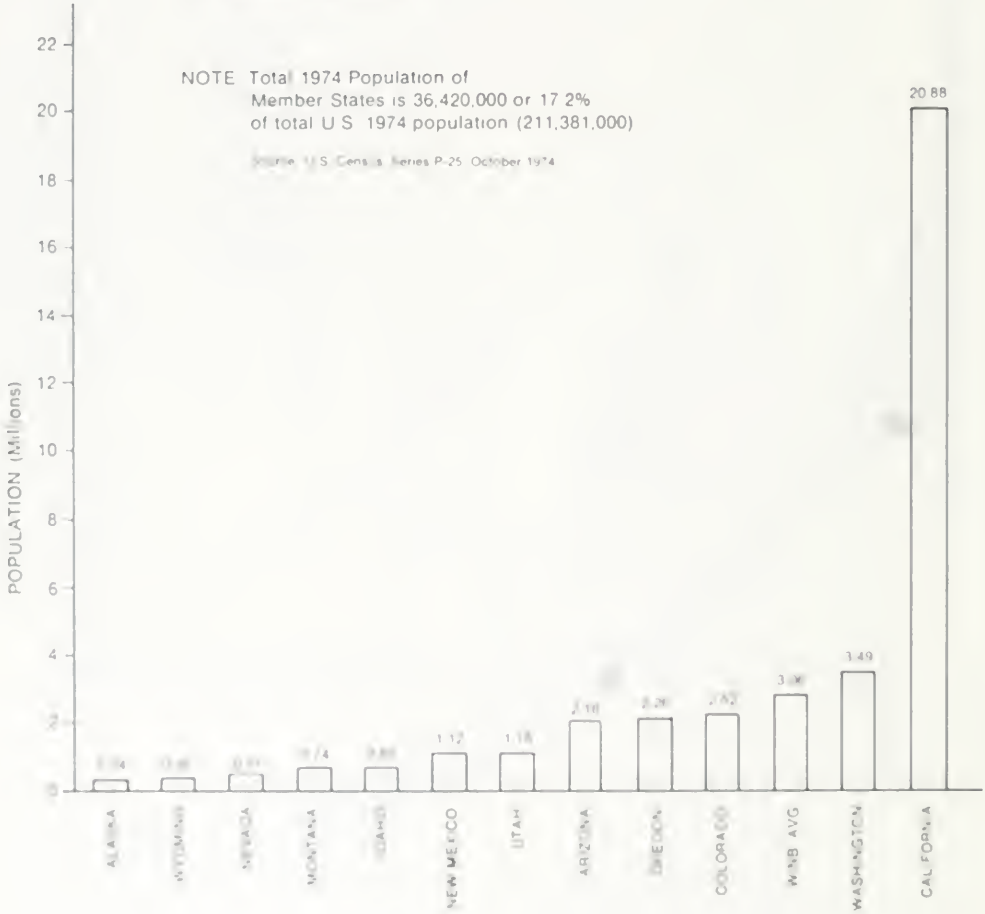


Figure 3-3

Figure 3-4

1974 Population in Western States



that California has a population which is seven times the average member state and about sixty times the population of the smallest member state.

It is interesting to note that even though California consumes more energy than any other member state that the consumption per capita is very low. States in which energy is abundant and fuel prices are low tend to have the higher consumption per capita as shown in Table 3-1 and in Figure 3-5.

Figure 3-5 includes electrical consumption as well as fossil fuel consumption. The electrical consumption, by state, is presented in Table 3-2. Note that 39 trillion kilowatt hours were exported by half of the member states. New Mexico and Wyoming were able to export over half of their electrical production. Such businesses bring greater tax base and employment to the Rocky Mountain States than would the simple export of coal.

California imported about 70% of the exportable electrical energy in the West in 1974. With the large natural gas deficit for California (Table 3-1) and the gross uncertainty of natural gas supplies for the coastal states, California will represent a much larger electrical energy market in the future than was the case in 1974. Much of the coal-fired generation described in Section 4.0 is devoted towards supplying some of the California market.

Since a majority of our energy will soon be delivered as electrical power, it is well to examine the public useage patterns both nationally and regionally. Figure 3-6 shows the national seasonal demands for electrical power. Note how the air conditioning loads in late summer have a pronounced effect on peak demands. The January cold weather also provides a special load for home heating which is noticeable. In the period from 1968 to 1973 the growth rate was a fairly steady 7 percent per year.

In the midst of the OPEC oil embargo (early 1974), the winter peak was slightly reduced only to have a new record set the following year (early 1975). Following the embargo, the peak associated with air conditioning was just as high as it had been the preceding year. The memory of the oil shortage was still there but the lesson appeared to be missing. Substitution of electrical energy for increasingly expensive liquid fuels partially accounted for keeping the electrical demand up.

Following the OPEC embargo electrical energy conservation decreased demand 10-15%, but only briefly. The demand has since increased. Higher electrical rates will stimulate noticeable voluntary conservation when electrical rates more nearly reflect the cost of new generation.

In anticipation of higher rates and lower demands, the utilities have deferred some of their scheduled new plants. Deferral is a simple tool and lets the utilities avoid investing more capital than necessary in new facilities. Difficulty in forecasting during the recent past has caused greater dependence on coal-fired generation since it can be added in smaller increments and in a much shorter time period.

Seasonal electrical demand peaks in the WINB member states are not as pronounced as the national peaks in Figure 3-6. As shown in Figures 3-7 and 3-8, the total of the twelve member states showed a modest late summer peak. This is probably due to the fact that the three largest electrical consuming states in the West all border the Pacific Ocean and that the population centers within those states are indeed close to the coastline. Of the smaller states, Arizona and Idaho are the only ones with prominent summer peaks, a portion of which is for agricultural pumping.

In general, the consumption patterns in the West appear destined to grow at a rate of about 1.5% per year due to population growth and about 3.5% due to increased activities in the industrial, commercial and residential sectors combined.

Table [illegible]

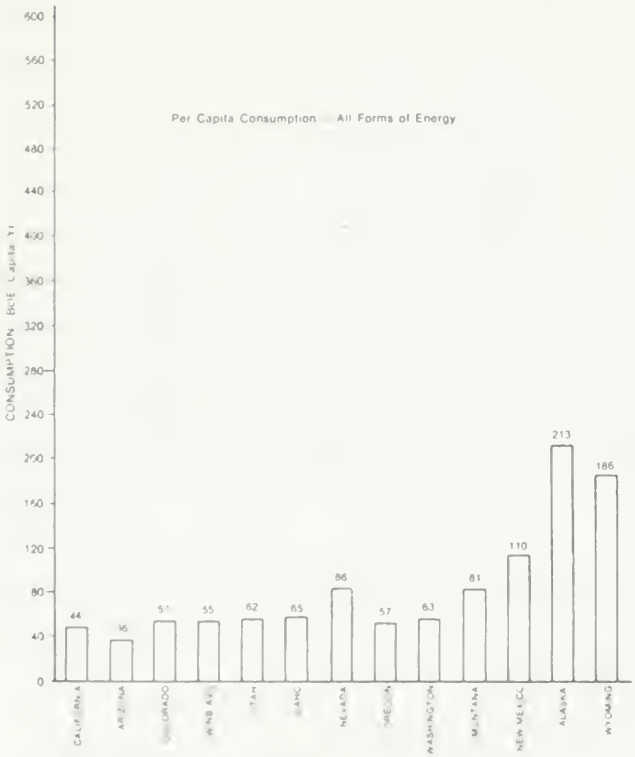
1974 Fossil Fuel Consumption and Production in the Western States

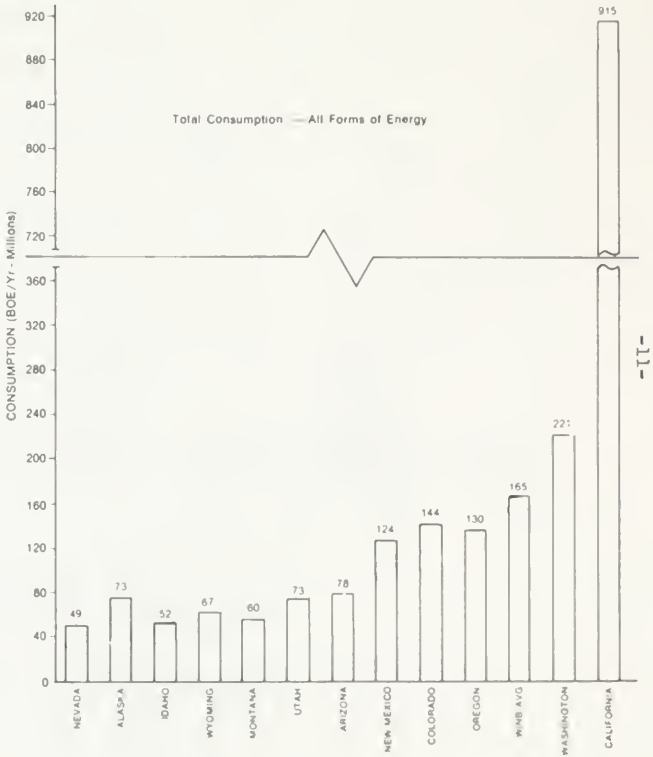
	Bituminous Coal[a] and Lignite (1,000 Tons)			Crude Oil[b] (1,000,000 Barrels)			Natural Gas[b] (1,000,000 Cu.Ft.)		
	Produced	Consumed	Net	Produced	Consumed[c]	Net	Produced	Consumed	Net
Alaska	400	630	1[illegible]	70.6	57.8	12.8	128,935	63,971	64,964
Arizona	[illegible]	3[illegible]	[illegible]	6.7	18.0	(1[illegible].3)	224	192,446	(192,222)
California	0	2104	(2104)	322.5	475.7	(153.2)	365,354	1,851,614	(1,486,260)
Colorado	6[illegible]0	7296	(3[illegible]4)	36.9	57.6	(20.7)	144,629	319,266	(174,637)
Idaho	0	472	(472)	0	23.4	(23.4)	0	53,057	(53,057)
Montana	14106	907	13199	34.8	25.5	9.3	54,873	80,776	(25,893)
Nevada	0	4375	(4575)	0.1	18.8	(18.7)	0	63,438	(63,438)
New Mexico	4392	2686	1706	93.5	38.9	54.6	1,244,779	312,422	932,357
Oregon	0	149	(149)	0	56.8	(56.8)	0	98,051	(98,051)
Utah	5858	4252	1606	39.2	33.0	6.2	50,522	124,973	(74,451)
Washington	3913	4167	(254)	0	82.9	(82.9)	0	182,723	(182,723)
Wyoming	20703	6731	13626	137.9	20.2	117.7	326,657	109,818	216,839
	68018	42182	25508	736.2	909.6	(173.4)	2,315,973	3,452,545	(1,136,572)

a) U.S. Bureau of Mines Annual Report on Coal--Bituminous and Lignite in 1974.
b) 1974 Production and Consumption Data by State, Independent Petroleum Producers of Amer. Ass'n.
c) Consumption is based on volume of petroleum products rather than volume of crude.

Figure 3-5

Energy Consumption in Western States - 1974





Source Data From Table 3-1 and Figure 3-4

Table 3-2

ELECTRICAL ENERGY PRODUCTION AND CONSUMPTION IN WESTERN STATES
(1,000,000 KW-HR)

State	Elect. Consumption[a]	Gross Production[a]	Net Production[b]	Net Imports	Net Exports	% Consumption Imported	% Production Exported
Arizona	20,286	20,532	17,863	2,417		11.9	
Alaska	1,624	1,860	1,618	6		0.4	
California	133,283	122,094	106,222	27,061		20.3	
Colorado	14,949	15,050	13,614	1,333		8.9	
Idaho	12,922	9,694	8,434	4,488		34.7	
Montana	9,169	11,055	9,618		449		4.7
Nevada	7,724	13,838	12,039		4,315		35.8
New Mexico	7,070	20,113	17,498		10,428		59.6
Oregon	30,646	35,293	30,705		59		0.2
Utah	7,201	4,038	3,513	3,688		51.2	
Washington	53,134	89,373	77,760		18,626		24.0
Wyoming	4,200	10,503	9,397		5,197		55.3
Total	306,261	354,349	308,283	38,993	39,074		

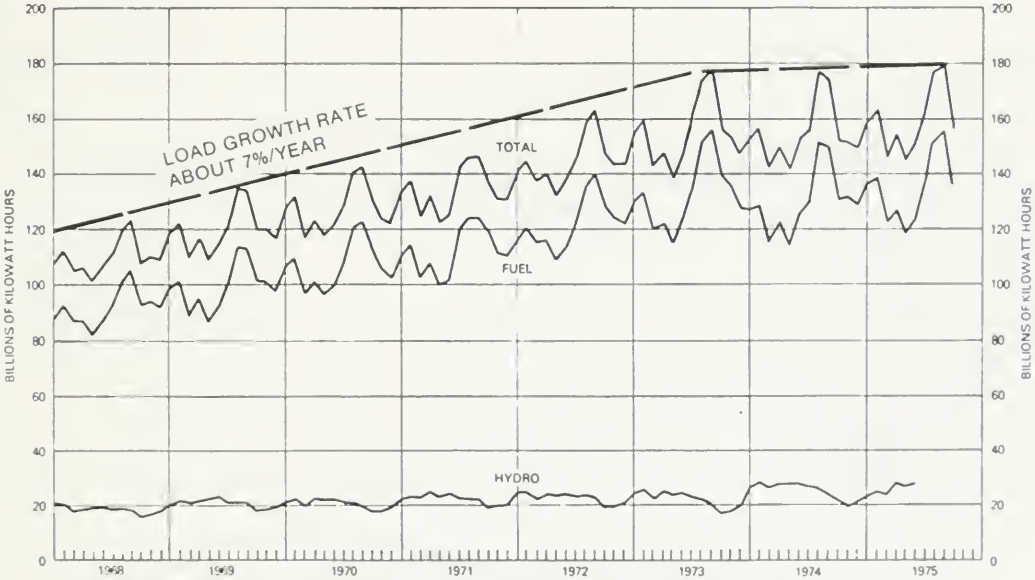
a) "Electric Power Statistics" Federal Power Commission--1974 (12 volumes)

b) Net production averaged 87% of gross production for Region. Equal losses assumed for each state.

Figure 3-6

Effect of 1973-74 Oil Embargo on Electrical Load Growth

Chart 1



Source "Electric Power Statistics" Federal Power Commission, June 1975

Figure 3-7

Seasonal Peaking of Electrical Sales in WINB Region and in States with Highest Demands - 1974

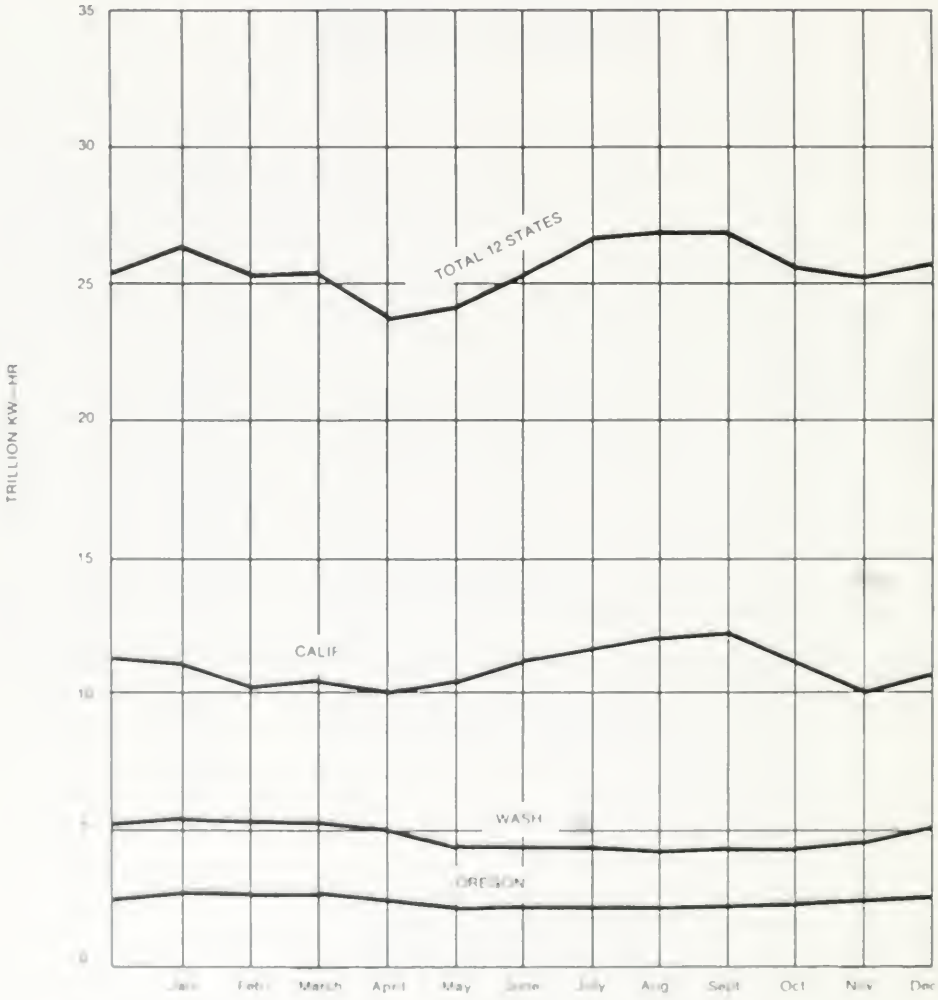
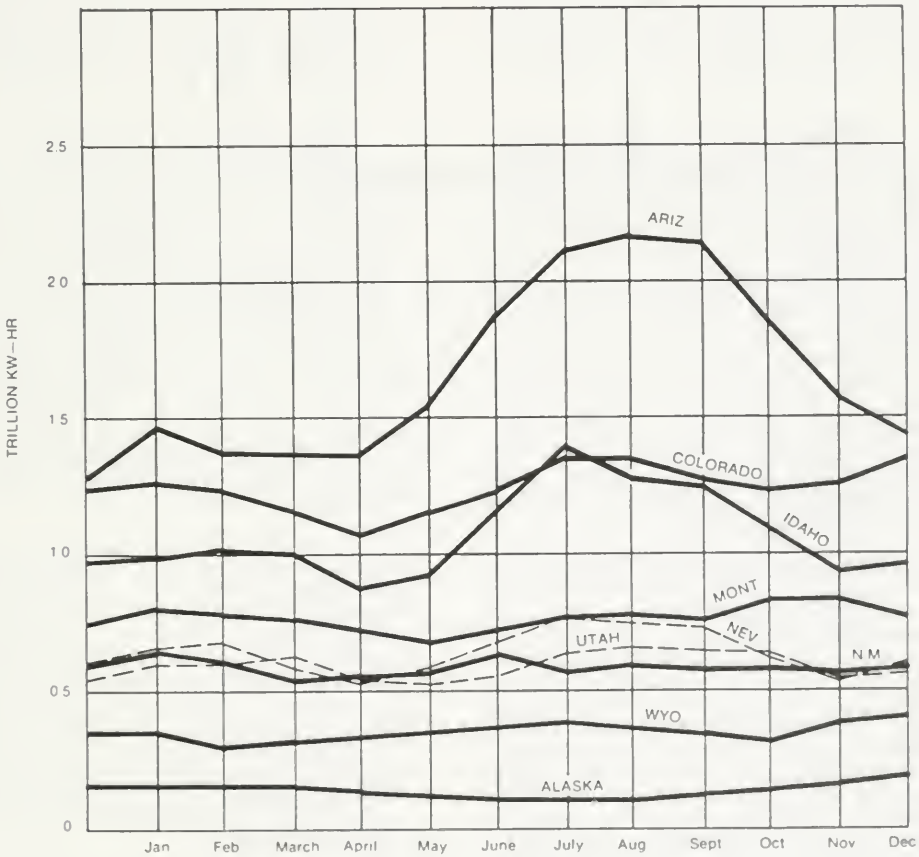


Figure 3-8

Seasonal Peaking of Electrical Sales in Balance of WINB Member States - 1974



Source: Electric Power Statistics, Federal Power Commission, June 1974, 12 Volumes

4.0 Energy Production in the West, 1970-1985

For each energy demand there is a producer. The producer may be within the state or perhaps even out of the region. In most cases, individual states have an excess of one form of energy and a deficit of others. It is helpful to compare the production and consumption on a state-by-state basis to predict where additional resources can be found.

For example, the large amounts of hydroelectric capacity in the Northwest makes the region ideal for meeting peaking loads and for providing low-cost energy during years with a high runoff. And the abundant coal resources of the Rocky Mountain States make them an ideal source for an early transition from oil and gas dependence. However, even abundant resources are finite. The Northwest appears reluctant to site additional hydroelectric facilities and some of the coal-rich states are wondering if they want to invest their future water supplies and air resources in more thermoelectric generation. Although energy independence by each state is not always possible, nor necessarily desireable, it does merit consideration.

Some states, such as Alaska, Wyoming, Montana and New Mexico have found that the role of being an energy exporter can bring new employment and tax base to their states and have been quick to take advantage of their fossil fuel resources. The State of Washington has pursued the export of energy derived from nuclear plants. Currently, Washington has eight nuclear power plants either planned, under construction or operating with an average rating of 1190 megawatts each. Other states such as Nevada and Arizona are recognizing the potential for importing coal and exporting the more valuable electrical product to a ready market in California.

Nuclear power and the Rocky Mountain coal resources make it possible for the western states to reduce (but not eliminate) their dependence on oil and gas. Although energy demands in the West will be met by about 40% electrical energy by 1980, the addition of Alaskan natural gas and oil will be a welcome addition to the fuel mix. By 1978, 300 million barrels of Alaska's exportable 438 millions barrels per year can be used to satisfy the deficit oil and natural gas position of the West Coast states. The balance presumably will be used in inland states such as Arizona, Idaho and Nevada.

The natural gas from Alaska is expected to be shipped or piped at a rate of about one trillion cubic feet per year. The natural gas imported by the coastal states in 1974 totaled about 1.8 trillion cubic feet. With indications from Canada that they would prefer to drastically reduce their gas exports to the Northwestern states, the Alaskan gas will fill a rapidly developing void. The inland states of Arizona, Idaho and Nevada had natural gas deficits totaling over 0.4 trillion cubic feet per year in 1974. Some of the inland states' needs can be filled with introduction of Alaskan natural gas into the same pipelines that had previously conveyed gas westward from El Paso, Texas.

A summary of 1974 fossil fuel production and consumption in the Western States is listed in Table 3-1. Electrical production and consumption for the same year is presented in Table 3-2. The combined quantities expressed as Barrels of Oil Equivalent (BOE) are displayed in Figures 4-1 and 4-2. Note that only Alaska, Montana, New Mexico and Wyoming were satisfying their own energy needs in 1974. With the addition of the eight nuclear power plants, Washington may also join the ranks of those states that produce more energy than they consume.

Arizona and Nevada can reduce their energy deficits by over 90% by addition of the twelve coal-fired plants scheduled for operation by 1981. By then, Oregon and Idaho may share the position of having the greatest energy deficit per capita of any state in the West.

Figure 4-1

Energy Production in Western States - 1974

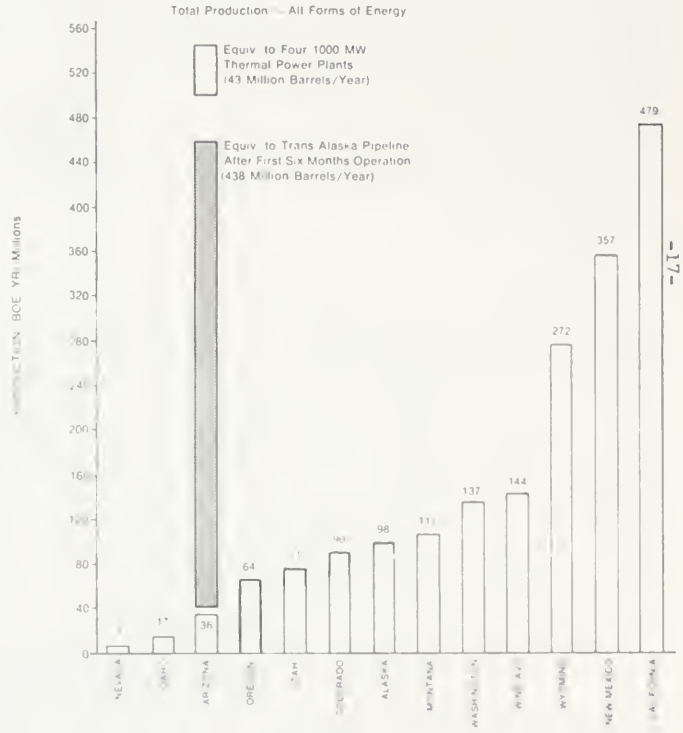
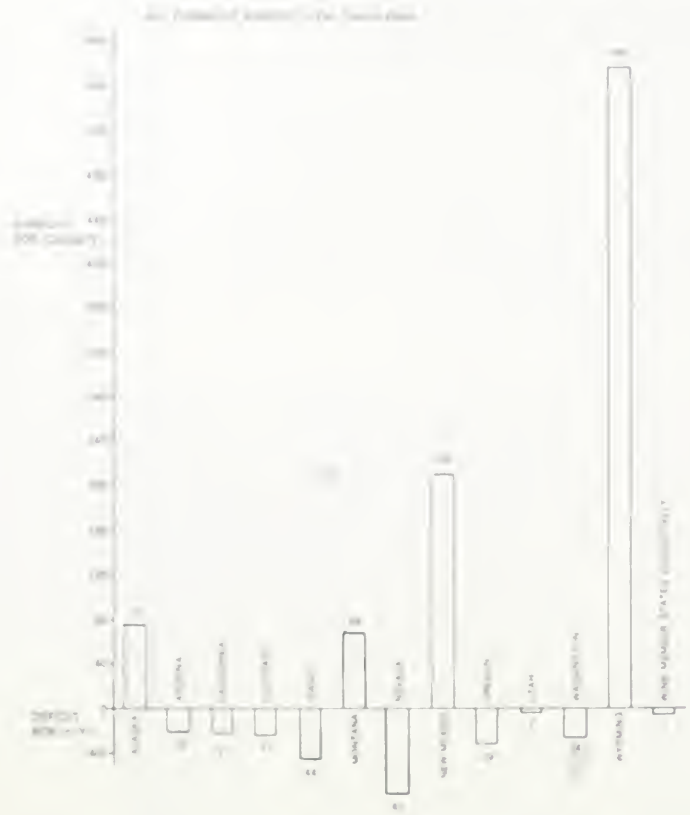
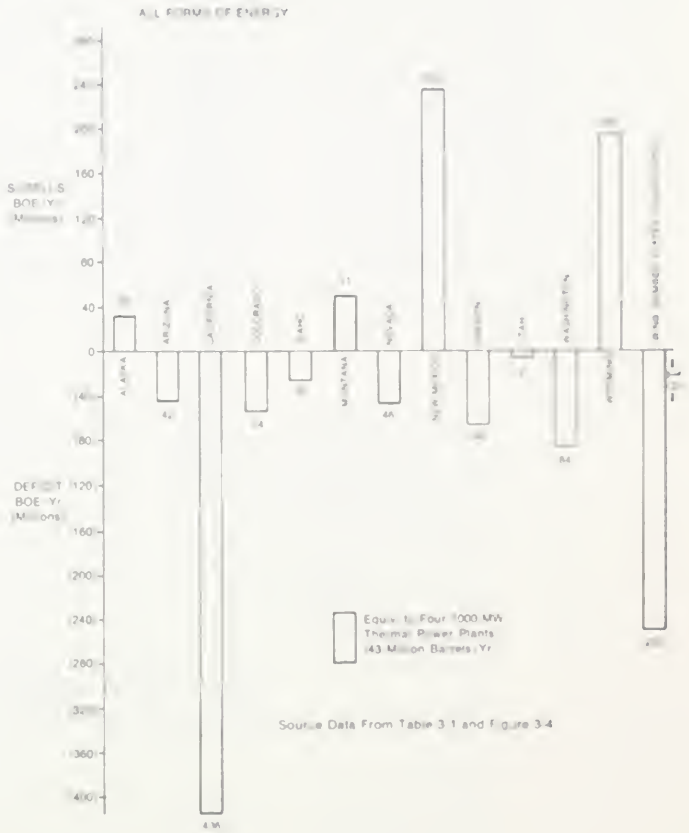


Figure 4-2

Net Energy Balances of Western States - 1974





The forms of energy produced and consumed in each state are presented in Figure 4-3. California's heavy dependence on gas and oil are easily illustrated. Even though California produces about half of the oil produced in the West, it has a deficit balance on oil and all other energy forms, especially natural gas. Most of the California natural gas deficit is currently made up by the surplus shown for New Mexico.

Three of the western states produce only hydroelectric energy. These states have built-in peaking facilities for the time when base-load coal-fired and nuclear generation are added. Meanwhile regional power interests are best served by interstate transmission lines and ample hydroelectric capacity to capture the peaking energy available in years with high runoff conditions. The same interstate lines can return base-load power in times of low water. A second interregional D.C. intertie is being considered again, to connect the Northwest with the Southwest. The second line may connect with the heavy thermal generation being built near Phoenix. The hydroelectric energy in the Northwest could then serve not only as a seasonal tool but also to meet daily peaking needs.

As in the case with the D.C. intertie to southern California, the power transfer agreements generally call for the total amount of energy transferred south to be equal to the amount returned to the Northwest. Therefore, the interties are not actually power transfers but instead simply load management tools.

The increased rate at which coal is being consumed in the WINB member states is best shown in Figure 4-4. Even though statistics on Nevada and Arizona have been combined, each consumed about 4000 tons of coal in 1974. Washington and Oregon statistics are combined, yet the coal use was primarily for the 1300 megawatt Centralia plant which began operation in Washington, during 1971. California's coal use is primarily for the manufacture of coke at the Fontana steel mill. Increasing industrial use of coal in the coastal states may become more common as the cost of all other energy commodities continues to escalate at a faster rate. Coal from Alaska can reportedly be delivered to West Coast ports at about $11 per ton or 77 cents per million BTU's, according to a 1974 report.[5]

Since Colstrip No. 1 did not begin operation until 1975, the Montana use of coal was still modest in 1974 but is expected to grow rapidly in the next ten years. Use of coal in New Mexico can be expected to rise dramatically when coal gasification plants are installed there.

The heavy coal use shown for Wyoming and Colorado are for the completed thermal-electric plants as listed in Table 4-1. Continued growth in Wyoming is expected to result in a production rate of about 75 million tons per year by 1985[6]. Figure 4-5 shows where known coal resources are in the West and where new facilities are being built to utilize those resources. The plants noted by circled numbers are listed in Table 4-2. Only those plants that have new units under construction, or are sited and scheduled for construction, are shown.

Colorado, New Mexico and Wyoming each converted about 7 million tons of coal into electrical power in 1974. Utah is attempting to follow the same pattern to return vitality to coal mining regions of the state. Utah has sufficient cooling water reserved for some very significant thermal-electric generation but has recently been frustrated in efforts to install 3000 megawatts (net electric) on the Kaiparowits Plateau.

Figure 4-5 shows some coal-fired generation outside the coal resource region. These sites are within easy rail-hauling distance and will share their output with electrical demands in the coastal states. Such plants generally are near a cooling water source and a transmission grid.

The existing coal-fired plants and those scheduled for operation are listed in Tables 4-1 and 4-2 respectively. Table 4-1 lists 5,263 MW of new capacity over that listed in the 1974 WINB Energy Report. Table 4-2 lists 17 additional units with an incremental addition of 5,598 MW. This list is adapted from published schedules of the western utilities[7] as of April 1, 1976. Most of the dates have been adjusted since 1974 to compensate for load schedule requirements.

---

[5] Stanford Research Institute "The Potential for Developing Alaskan Coals for Clean Export Fuels-Phase I" December 1974

[6] Final Task Force Report on Coal, FEA Project Independence Blueprint U.S. Dept. of Interior. November 1974.

[7] Western Systems Coordinating Council Reply to Federal Power Commission Docket R-362, April 1, 1976.

Figure 4-3

Energy Forms Involved in Production and Consumption in Western States - 1974

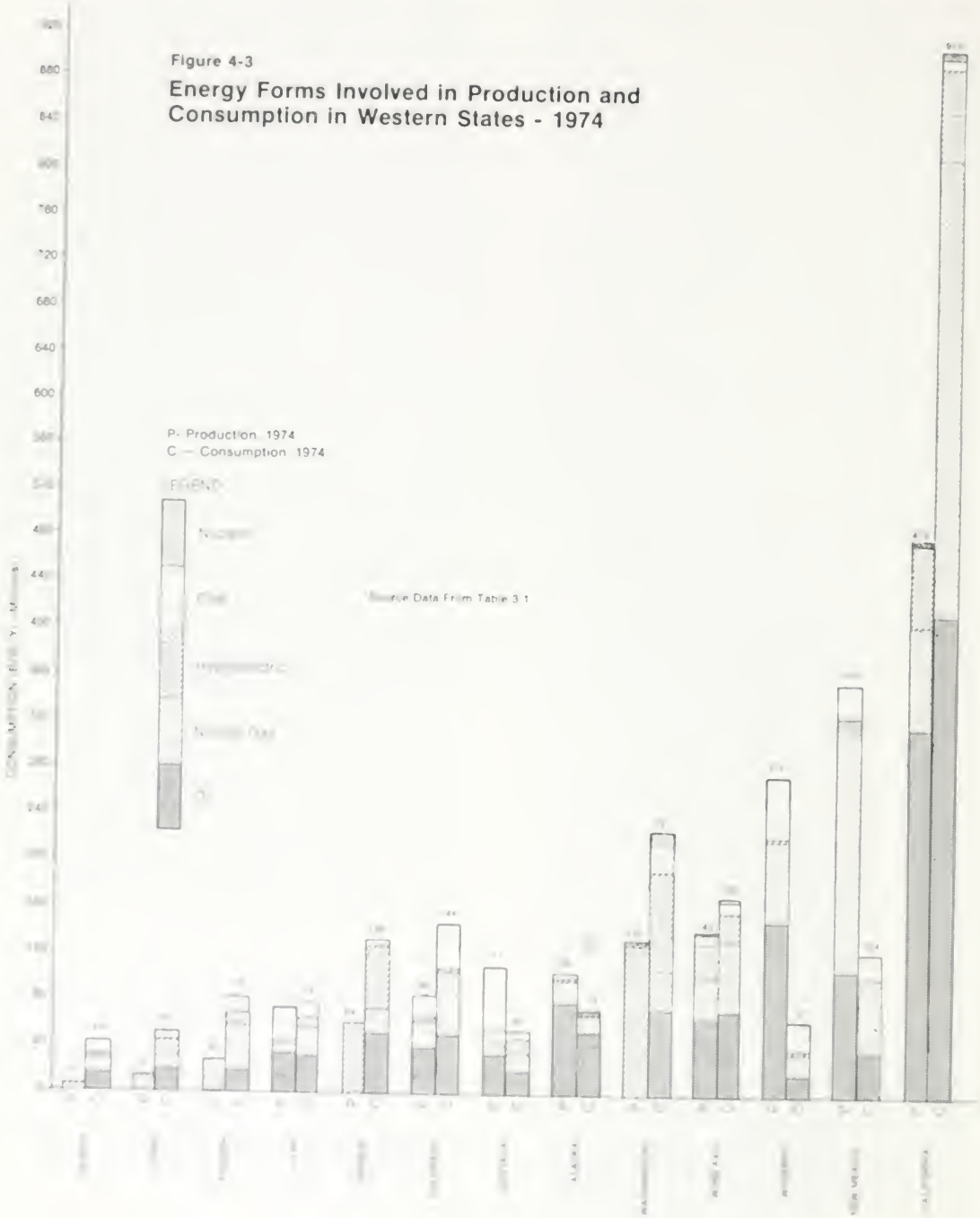
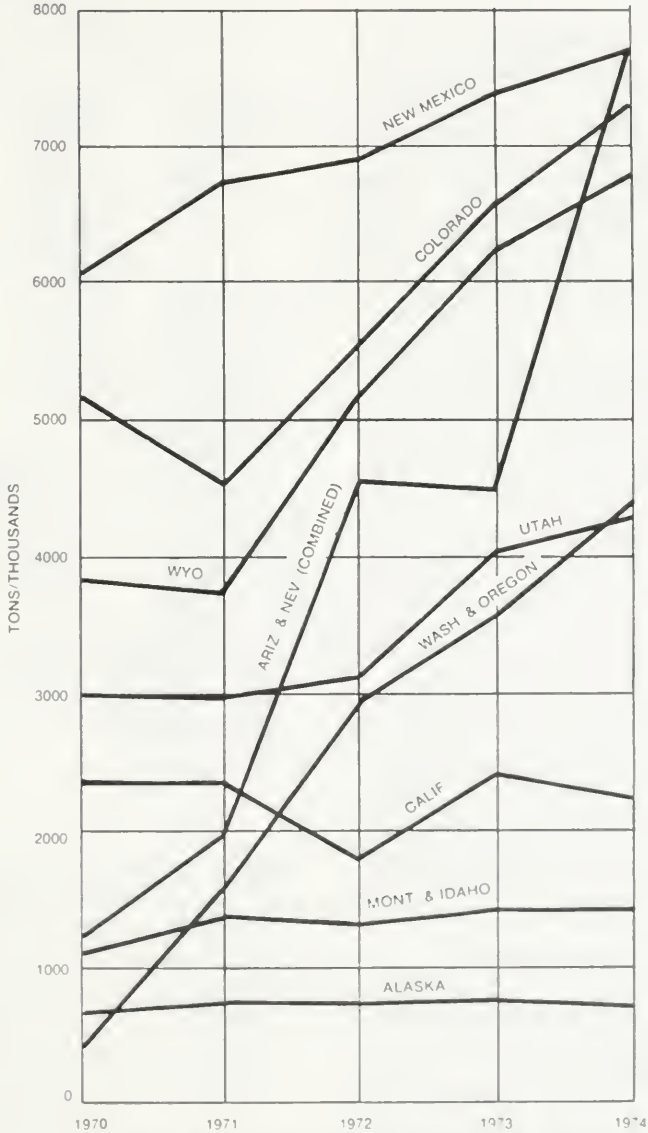


Figure 4-4

Use of Bituminous Coal and Lignite in WINB Member States



Source: "Coal - Bituminous and Lignite in 1974", U.S. Bureau of Mines, Jan. 27, 1976.

Scheduled Coal-Fired Plant Locations in WINB Member States (as of June 30, 1976)

Figure 4-5

Table 4-1

Locations of Existing Coal-Fired Electrical Generation in the West
(as of June 30, 1976)

Location of Units	Rating
Healy, Alaska	54 MW
Joseph City, Arizona	116
Page. "	2,250
Canon City, Colorado	43
Colorado Springs, "	261
Denver, "	942
Grand Junction, "	75
Pueblo, "	670
Boulder, "	175
Hayden, "	180
Nucla, "	36
Billings, Montana	180
Colstrip "	330
Mohave, Nevada	1,580
Moapa, "	337
Farmington, New Mexico	2,167
San Juan, " "	330
Orem, Utah	63
Salt Lake City, Utah	180
Castle Gate, "	171
Huntington, "	415
Centralia, Washington	1,300
Osage, Wyoming	35
Wyodak, "	23
Kemmerer, "	710
Glenrock, "	750
Rock Springs, Wyoming	1,000
Total	14,373

Source:
Adapted from Western Systems Coordinating Council April 1976 listing of existing and scheduled thermal generation facilities.

The Hat Creek plant complex in British Columbia is a noteworthy addition. The subbituminous coal at Hat Creek is apparently of such low heating value that it can best be "exported by wire". By contrast, the Kaiparowits coal is a good bituminous grade and can be rail-hauled to other locations if a decision is made to not build generation facilities on the Kaiparowits Plateau. Mining of the Kaiparowits coal has been assured. Destination points could include any of the western states.

The existing and scheduled nuclear power projects in the West are all listed in Table 4-3, and shown by circled numbers in Figure 4-6. Only two have been completed since the 1974 WINB Energy Report for an increase of 2,043 MW. These two were the Trojan Nuclear Plant in Oregon (figure 4-7) and the Rancho Seco Nuclear Plant in California (figure 4-8). The Trojan plant is rated at 1130 megawatts (net electric) and the Rancho Seco plant at 913 megawatts. Four additional units have been listed for completion by the end of 1985 for an expected increase of 5,337 MW. Seven additional nuclear units are planned for commercial operation in the following three years (1986-1988). The added capacity associated with the next seven would be 9,250 MW. Greater certainty with respect to both load growth and availability of capital will be needed before the planned plants can become scheduled projects.

Most noteworthy in the nuclear plant list is the planned retirement, in 1977, of the nation's only power reactor without a containment vessel. The Hanford No. 1 was long a leader in production of nuclear kilowatt hours and has served the Northwest well in years of low runoff.

The schedule shown for the Diablo Canyon plants is tenuous due to continuing seismic investigations. Estimates are that the plant startups could each be delayed about one year.

The Ft. St. Vrain plant rise to full power is expected to take place in the fall of 1976. The Ft. St. Vrain plant is the only high-temperature gas-cooled reactor to be operating in the West. Public Service Company of Colorado has a 13-year contract for fuel. If, during this 13-year period the reactor performance is satisfactorily demonstrated, the high-temperature gas-reactor could be considered a possible heat source for future coal gasification plants.

In general, the development of nuclear generation in the West has been slow, compared with steady growth of coal-fired electrical generation. There is no indication that between now and 1985 that this pattern will be altered. The existing, scheduled and planned generation listed in Tables 4-1, 4-2 and 4-3 have been graphically presented in Figure 4-9. The decreased slope on the coal-fired curve towards

Table 4-2

Coal-Fired Electrical Generation Plants
Scheduled or Under Construction in the WINB Member States

Operational	Site	Name	Rating, MW (net electric)	Location
All existing to June 30, 1976			14,319 megawatts	West
July 1976	9	Hayden No. 2	250	Colorado
July 1976	8	Colstrip No. 2	330	Montana
Oct. 1976	5	Bridger No. 3	500	Wyoming
Dec. 1976	2	San Juan No. 1	326	N. Mexico
June 1977	6	Huntington Canyon No. 1	400	Utah
June 1977	6	Huntington Canyon No. 2	415	Utah
April 1978	9	Craig No. 1	380	Colorado
May 1978	11	Wyodak No. 1	330	Wyoming
June 1978	10	Cholla No. 2	250	Arizona
June 1978	14	Emery No. 1	400	Utah
Sept. 1978	16	Apache No. 2	175	Arizona
April 1979	7	Pawnee No. 1	500	Colorado
April 1979	1	Coronado No. 1	350	Arizona
April 1979	9	Craig No. 2	500	Colorado
May 1979	2	San Juan No.3	466	N. Mexico
June 1979	15	Cholla No. 3	250	Arizona
June 1979	16	Apache No. 3	175	Arizona
Oct. 1979	12	Nixon No. 1	200	Colorado
Dec. 1979	5	Bridger No. 4	500	Wyoming
Jan. 1980	3	Laramie No. 1	500	Wyoming
April 1980	1	Coronado No. 2	350	Arizona
April 1980	14	Emery No. 2	400	Utah
June 1980	10	Cholla No. 4	350	Arizona
July 1980	8	Colstrip No. 3	700	Montana
July 1980	21	Boardman	500	Oregon
Oct. 1980	17	Valmy No. 1	250	Nevada
April 1981	4	* Pioneer No. 1	500	Idaho
April 1981	7	Pawnee No. 2	500	Colorado
May 1981	2	San Juan No. 4	466	N. Mexico
June 1981	18	Warner Valley No. 1	250	Utah
July 1981	9	Craig No. 3	380	Colorado
July 1981	8	Colstrip No. 4	700	Montana
Jan. 1982	19	Plains No. 1	180	N. Mexico
April 1982	20	Naughton No. 4	400	Wyoming
June 1982	18	Warner Valley No. 2	250	Utah
June 1982	13	H. Allen No. 1	500	Nevada
July 1982	9	Craig No. 4	380	Colorado
Jan. 1983	23	Hat Creek No. 1	500	B. Columbia
April 1983	22	Southeastern No. 1	500	Colorado
April 1983	4	* Pioneer No. 2	500	Idaho
May 1983	11	Wyodak No. 2	132	Wyoming
June 1983	13	H. Allen No. 2	500	Nevada
June 1983	3	Laramie No. 2	500	Wyoming
June 1983	24	Thermal No. 1	500	California
Oct. 1983	23	Hat Creek No. 2	500	B. Columbia
Oct. 1983	17	Valmy No. 2	250	Nevada

Table 4-2 (cont'd)

Operational	Site	Name	Rating, MW (net electric)	Location
Jan. 1984		Intermountain No. 1	750	Utah
April 1984	20	Naughton No. 5	400	Wyoming
June 1984	13	H. Allen No. 3	500	Nevada
June 1984	24	Springerville No. 1	330	Arizona
Oct. 1984	23	Hat Creek No. 3	500	B. Columbia
Jan. 1985		Intermountain No. 2	750	Utah
April 1985	22	Southeastern No. 2	500	Colorado
June 1985	13	H. Allen No. 4	500	Nevada
July 1985	23	Hat Creek No. 4	500	B. Columbia
Oct. 1985	12	Ray Nixon No. 2	200	Colorado
Oct. 1985		Unknown No. 1	250	Nevada
Ja. 1986		Intermountain No. 3	500	Utah

Total scheduled for after June 30, 1976 24,365 MW

Total existing and scheduled 38,738 MW

Source: Adapted from Western Systems Coordinating Council April 1976 reply to FPC.

* Not yet approved by the Idaho Public Utilities Commission.

the end of the forecast period is most likely due to incomplete data rather than a trend reversal. The figure shows that coal-fired generation is moving along swiftly and that the coal-fired plants are no longer on a convergent path with nuclear plants as was the case just three years ago. At that time, nuclear capacity was expected to exceed coal-fired capacity by 1987. Presently there is no indication that nuclear will exceed coal-fired capacity within the current century.

The electrical generation mix can now be predicted for 1985. Figures 4-10 and 4-11 show the resource mix both as it existed at the end of 1974 and as it is expected to be at the end of 1985. Even though a large sector is shown as Hydro, much of the hydro-capacity is available for peaking rather than for steady generation. The coal and the nuclear sectors will normally be operated with high capacity factors. The gas and oil sector actually shows a decreased capacity due to the planned phaseout of such plants, especially in California.

Even though geothermal capacity is expected to quadruple in the next ten years, it is expected to be able to handle only 1.3% of the demands by 1985. Other developing technologies such as solar-electric, MHD, thermalgradients, windpower, etc. are not yet expected to be significant by 1985.

Analysis of the shifting capacities within the next decade is shown in Figure 4-12. The figure shows a steady decrease in dependence on oil and gas with steady gains by coal and nuclear power. The hydro percentage decreases only because of the larger total generation capacity.

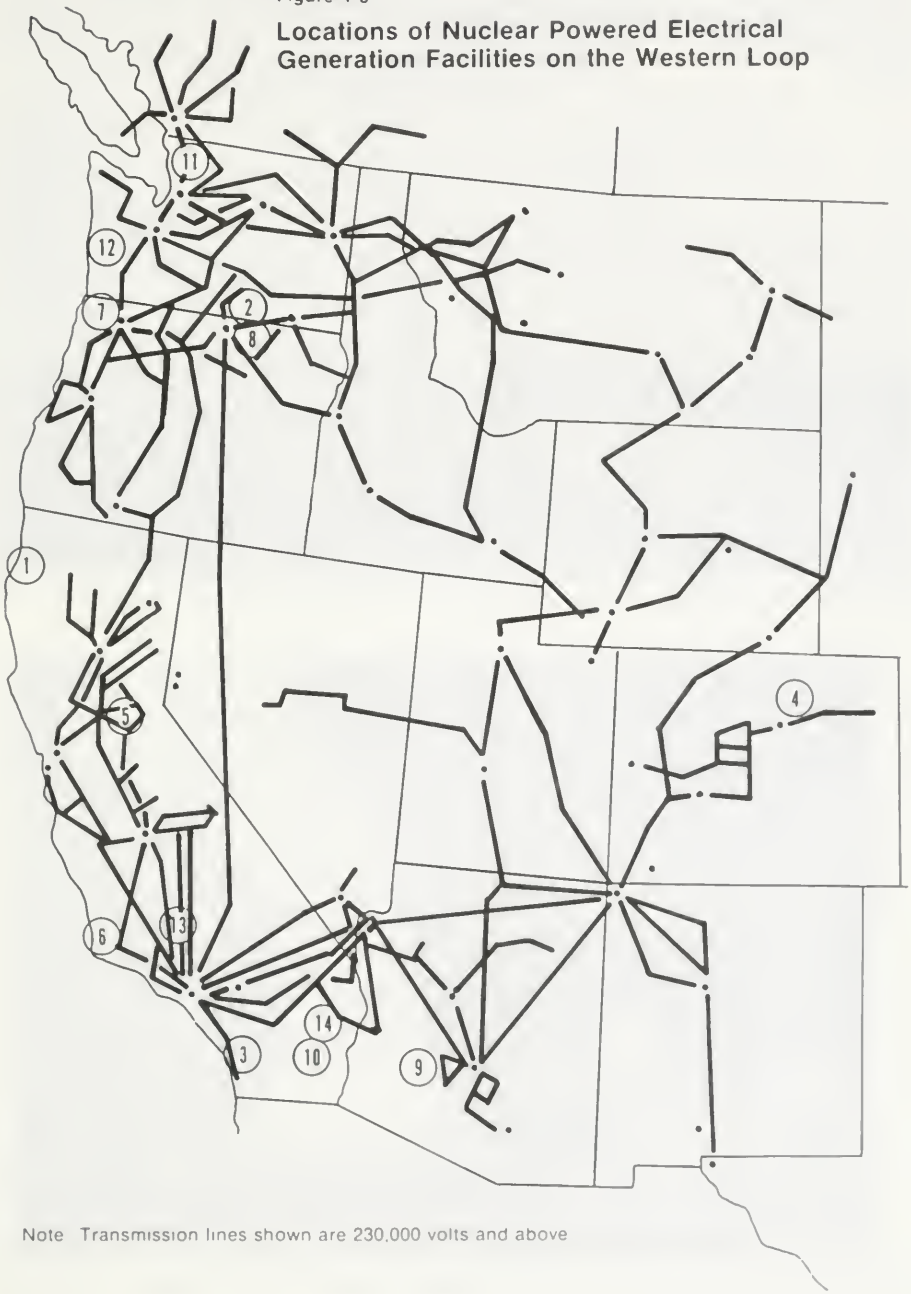
Table 4-3
Existing and Scheduled Nuclear Power Plants
in the WICHE Member States (as of June 30, 1976)

Existing	Name	Rating (net electric)	State	Site
1[illegible]3	Humboldt	63 megawatts	California	1
1[illegible]	Hanford No.1	862	Washington	2
1[illegible]7	San Onofre No. 1	430	California	3
1975	Rancho Seco No. 1	913	California	5
1976	Trojan	1130	Oregon	7
	Sub-total	33[illegible]8		
Scheduled				
Aug. 1976	Ft. St. Vrain	330	Colorado	4
Aug. 1976	Diablo Canyon No.1	1060	California	6
Aug. 1977	Diablo Canyon No.2	1060	California	6
Nov. 1977	Hanford No. 1	(862)	Washington	2
July 1979	WPPSS No. 2	1100	Washington	2
March 1981	WPPSS No. 1	1250	Washington	2
Oct. 1981	San Onofre No. 2	1100	California	3
March 1982	WPPSS No. 3	1240	Washington	12
March 1982	WPPSS No. 4	1250	Washington	2
May 1982	Palo Verde No. 1	1270	Arizona	9
Jan. 1983	San Onofre No. 3	1100	California	3
July 1983	Skagit No. 1	1288	Washington	11
Sept. 1983	WPPSS No. 5	1240	Washington	12
May 1984	Palo Verde No. 2	1270	Arizona	9
Dec. 1984	San Joaquin No. 1	1300	California	13
May 1985	Sundesert No. 1	950	California	10
July 1985	Pebble Springs No.1	1260	Oregon	8
1986	Palo Verde No. 3	1270	Arizona	9
1986	San Joaquin No. 2	1300	California	13
1986	Skagit No. 2	1288	Washington	11
1987	San Joaquin No. 3	1300	California	13
1988	Vidal No. 1	1540	California	14
1988	Pebble Springs No.2	1260	Oregon	8
1988	San Joaquin No. 4	1300	California	13
	Sub-total	[illegible]		
	Total	[illegible] megawatts		

Source: Adapted from Western Systems Coordinating Council April 1976 listing of existing and scheduled thermal generation facilities.

Figure 4-6

Locations of Nuclear Powered Electrical Generation Facilities on the Western Loop



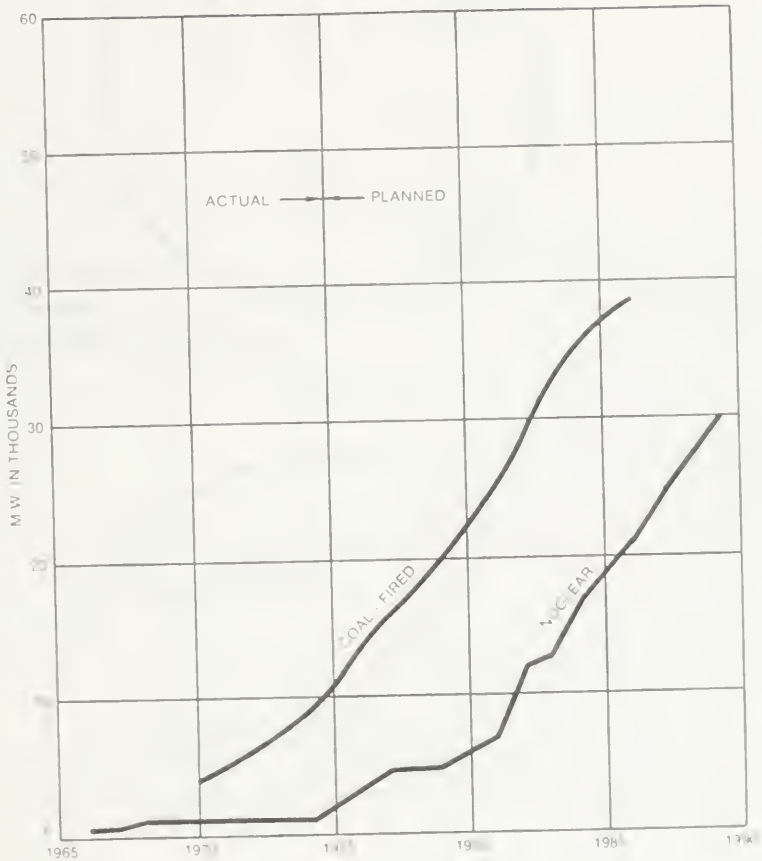
Note Transmission lines shown are 230,000 volts and above

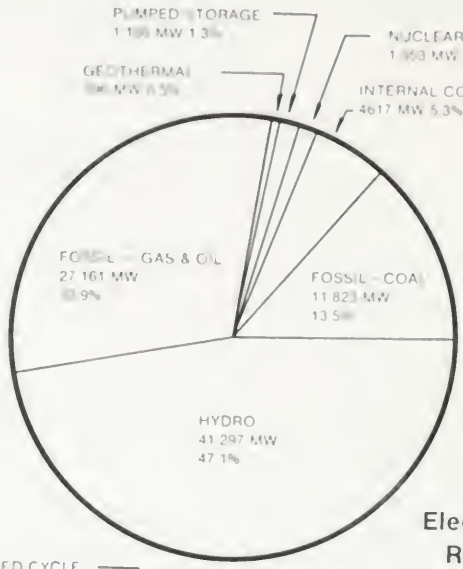
Figure 4-7 Rancho Seco Nuclear Plant No. 1 near Sacramento, California.

Figure 4-8 Trojan Nuclear Plant in Operation near Portland, Oregon.

Figure 4-9
Growth Patterns of Coal-Fired and Nuclear Thermal-Electric Generation in WINB Region

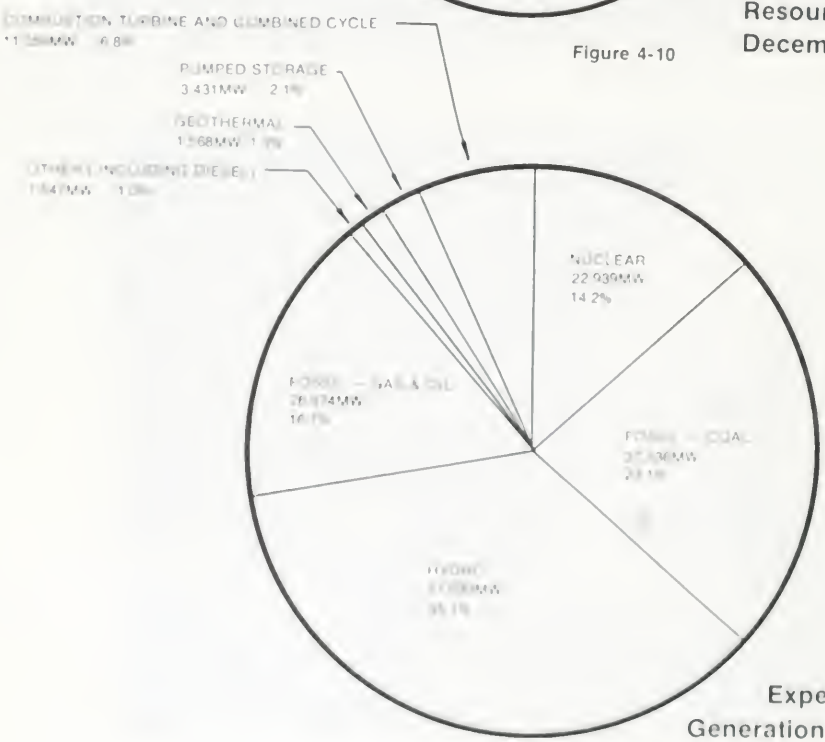
Source: Adapted from WUCC FA[illegible]





Electrical Generation Resource Mix as of December 31, 1974

Figure 4-10



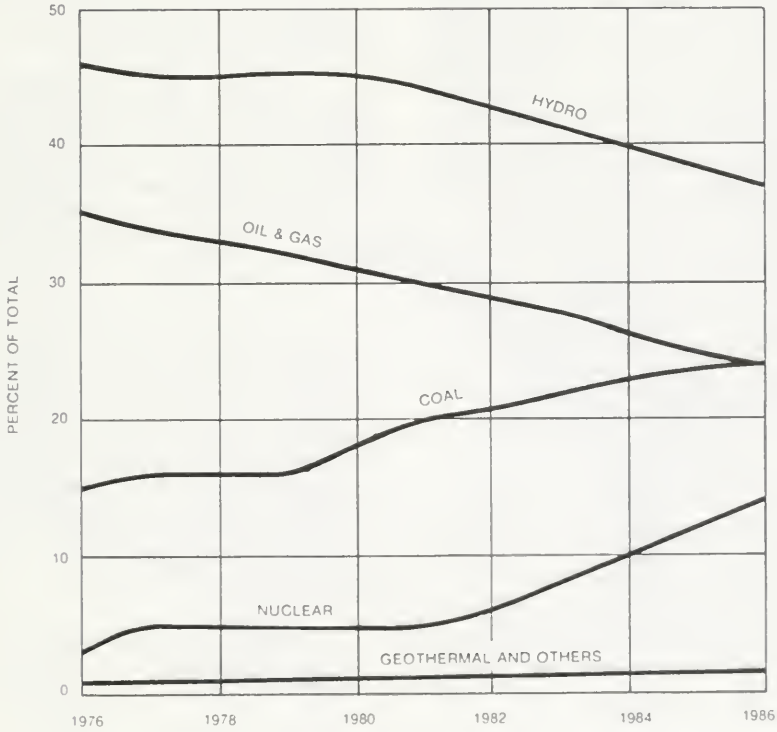
Expected Electrical Generation Resource Mix as of December 31, 1984

Figure 4-11

Figure 4-12

Trends in Electrical Generation Capacities in Western States

Source: Adapted from WSCC 1976 Capacity Plans as submitted to FPC, April, 1976



5.0 Energy Resources Under Development in Region, 1976-1986

The OPEC oil embargo, and the economic recession that followed, helped to create an awareness that our nation was becoming increasingly dependent on a narrow base of diminishing resources.

With little strategic storage of oil and natural gas and with little effort towards energy conservation, the federal government hastily implemented a program referred to as Project Independence. The goals of the program are generally to become only tolerably dependent on imported oil and gas and be able to be essentially self-sufficient as a nation by 1985.

Although little constructive efforts towards energy independence were accomplished in 1974 or 1975, by early 1976 the national economy was recovering with much of the economic activity directed towards the development of domestic energy resources. The largest single construction project, the trans-Alaska pipeline, was underway and similar large undertakings were being planned such as a natural gas pipeline from Alaska, a private uranium enrichment plant and the leasing of 30 million acres on the Outer Continental Shelf. Interest in synthetic fuels from oil shale, tar sands and coal temporarily dimmed due to the uncertainty of both natural gas and imported oil prices.

Since many of the domestic energy expansion efforts directly affect the West, this section deals with how these developing activities affect the region as of June 30, 1976. The treatment is by no means comprehensive, but should serve to show that much of the region is making a diligent effort towards making the nation energy independent by 1985.

5.1 Oil

Even though petroleum resources in the U.S. are diminishing, the efforts to expand the production base has not lessened. The primary petroleum project in the West is in Alaska where a $7 billion pipeline is being readied to deliver 1.2 million barrels per day to the Port of Valdez. Deliveries are to begin by the end of 1977 and to increase in capacity by 25% within the first 18 months of operation. The oil will presumably be delivered to the refineries along the West Coast. Advent of the oil along the coast should help to displace a nearly equal quantity originating in California and New Mexico.

Oil is produced in seven of the twelve WINB member states as shown in Table 3-1. New Mexico and Wyoming each produced about 100 million barrels in 1974; yet their combined total was less than half of the California production. Alaska ranked fourth in 1974 but will clearly be the leading oil producer in the West when the Prudhoe Bay oil begins flowing.

It is suspected that there is considerably more oil in Alaska than has been heretofore discovered. To assess the true extent of the oil resources there, the federal government intends to lease more of the Outer Continental Shelf near Alaska. Those portions of greatest interest are shown in Figure 5-1. The necessity for finding more oil in Alaska, at this time, has been disputed. Much of the area under scrutiny is in a seismically active region and is the home for much of Alaska's fishing industry.

Idaho, Oregon and Washington have no known commercial oil or natural gas resources.

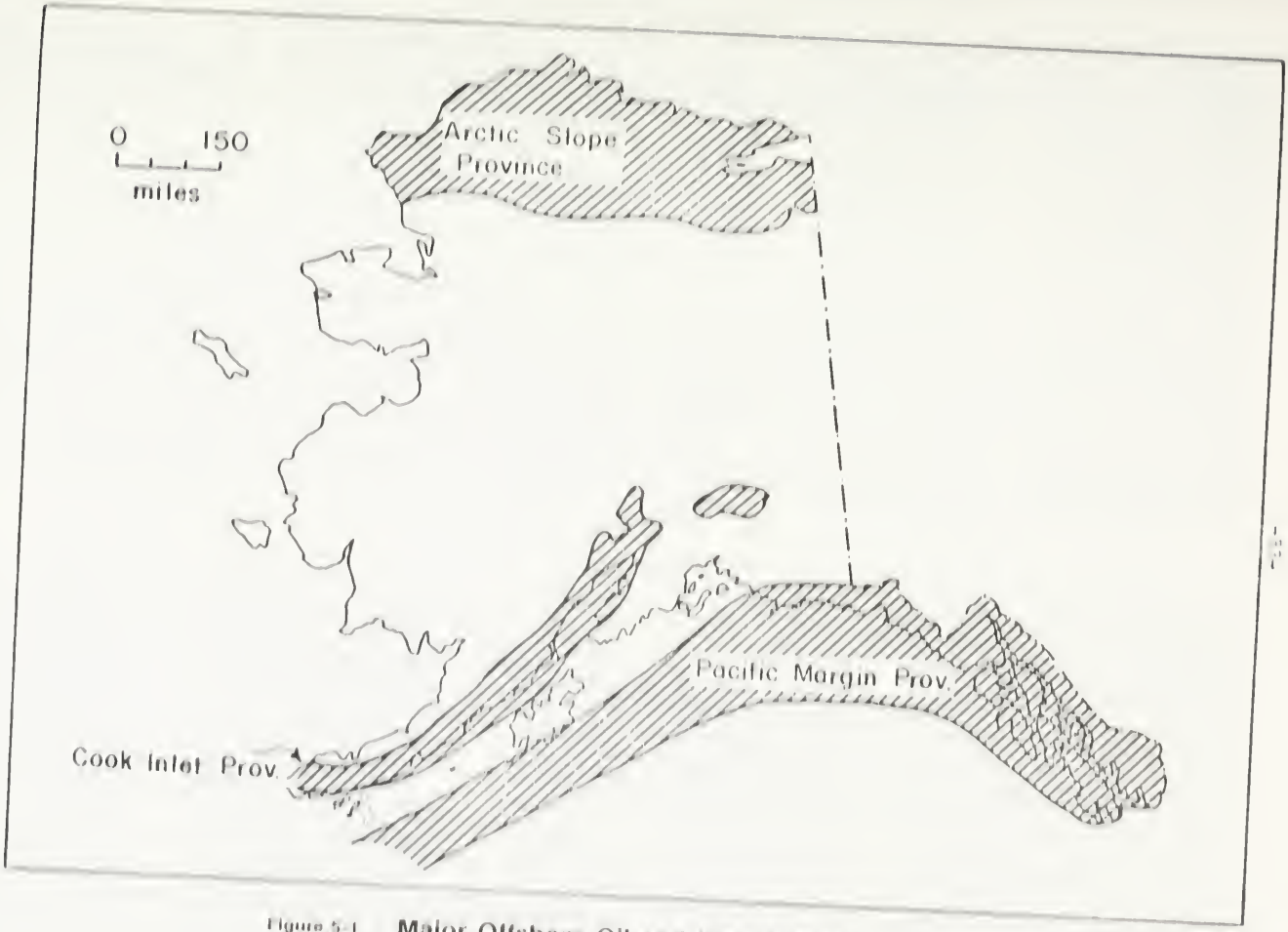


Figure 5-1 **Major Offshore Oil and Natural Gas Exploration Areas in Alaska** Source: MMS, 1979

Oil from oil shale and tar sands has been within the grasps of technologists for many years but has not been economic due to the very low cost of imported oil. With imported oil approaching $15 per barrel recovery from shale and tar sands has reached a high level of interest. The Department of Interior has leased oil shale tracts in Colorado and Utah to encourage private investment along these lines. To further stimulate interest in synthetic fuels, the Congress is considering various economic incentives to reduce the great degree of risk currently inhibiting private sector investment in synfuel development.

One proposal includes federal loan guarantees which would be available, not only for development of an oil shale industry, but also for development of synthetic oil (syncrude) and synthetic gas (syngas) from coal. The syncrude and the oil from shale could be used as feedstock in existing refineries as shown in Figure 5-2. The syngas would be used primarily as fuel for electric utilities.

The location of the oil shale leases is shown in Figure 5-3. They are all in a geological formation known as the Green River Formation. The mining methods to be used in each site will be different.

5.2 Natural Gas

A similar account can be given for natural gas as presented for oil. New Mexico produces over 50% with California and Wyoming, each producing about 15% of the production in the West. When Alaska's gas delivery system is operational, it will be on a par with the 1974 New Mexico production. Whether the 30 trillion cubic feet of Prudhoe Bay gas will displace New Mexico gas or stimulate new uses depends on the federal gas regulations in effect at that time.

The Federal Power Commission is currently investigating the best way to transport the gas from Prudhoe Bay to the Western U.S. Three private proposals are being reviewed with approval likely for only one. Figure 5-4 illustrates the routes proposed in the three plans. El Paso Natural Gas Company has proposed an "All-American" plan parelleling the Trans-Alaska Pipeline with conversion to liquefied-natural gas (LNG) prior to transport to the California coast. Arctic Gas Pipeline Company has proposed a route that is essentially all within Canada and could be used to move Canadian gas as well. Alcan Pipeline Corporation has submitted an intermediate plan that follows the trans-Alaska pipeline for about 300 miles and then heads south along the Alcan Highway.

Approval of a single plan by FPC is not expected before July 1977. Starting construction thereafter, the pipelines could be operational by either early 1980 or early 1982, depending on the plan selected. According to the applications, only the proposed Alcan Pipeline Corp. project could be completed by 1980. Costs for the project are expected to range from $7 to $12 billion.

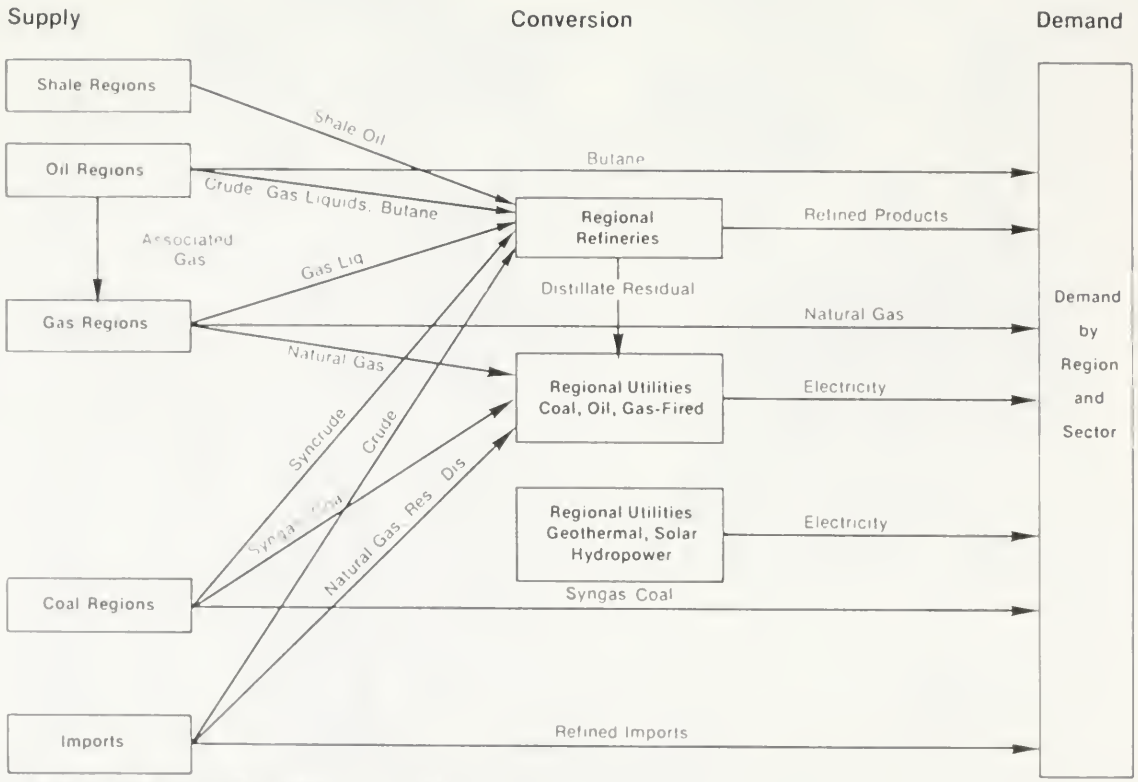
Alternate plans include conversion of the natural gas to methanol at Prudhoe Bay with pipeline, then tanker transport from Valdez.

The impact of Alaska's natural gas to the region's production will be large (see Figure 5-5), and the impact to the West Coast basins with atmospheric inversion problems could be very important. Many of Southern California's power plants are within the Los Angeles Basin and are only reluctantly permitted to substitute oil for gas. Until greater electrification can be accomplished in the West, and some of the metropolitan plants retired, natural gas will be a precious commodity in many geographic areas and in many sectors of the region's economy. The growth of the natural gas market implied by Figure 5-5 will depend on the prices allowed for this fuel commodity over the time period shown.

Probably the dominant force in the availability of natural gas is the price for which it may be sold. As long as it is controlled at a low price, it appears that the availability will continue to decline at a rapid rate. If it could be sold, in interstate systems, at the same price per million BTU's as oil, it is expected that the availability would grow at the rate shown by FEA in Figure 5-6. Meanwhile, most of the new natural gas discoveries are being dedicated to the unregulated intrastate distribution systems

Figure 5-2

Placement of Shale Oil Syncrude and Syngas into Commercial Outlets



Source: 1976 National Energy Outlook, Federal Energy Administration, Feb. 1976

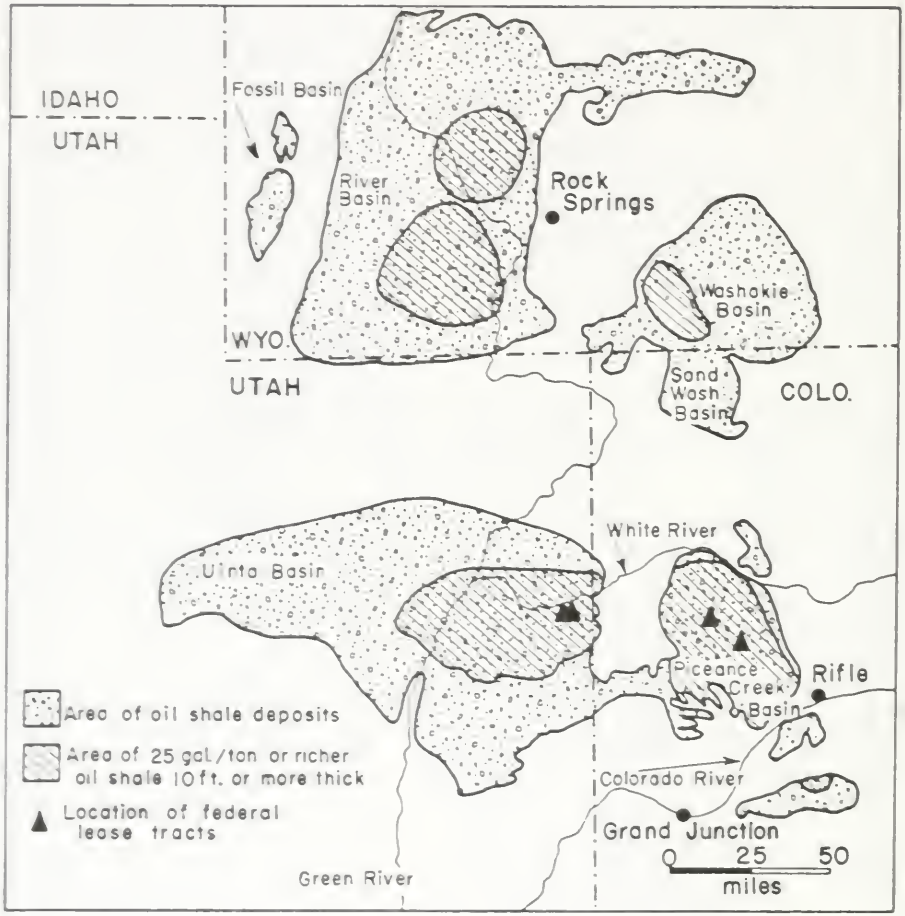
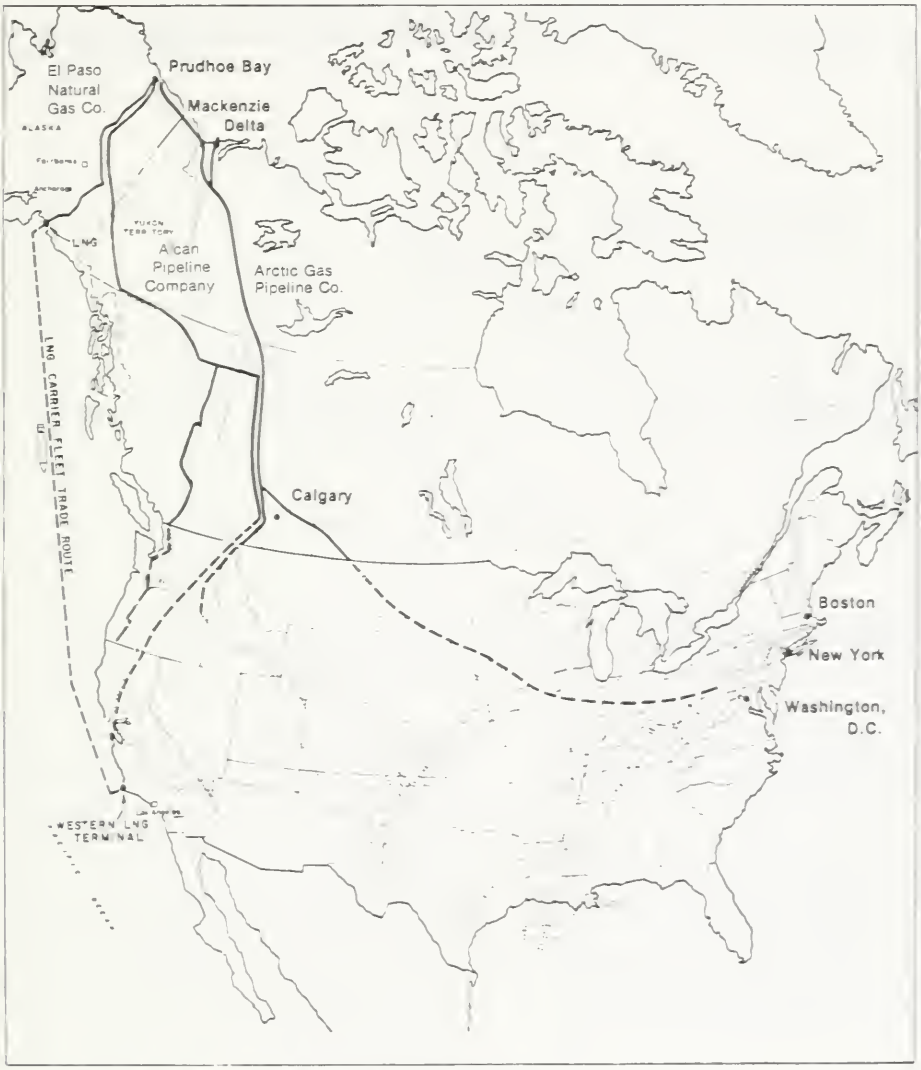


Figure 5-3

Location of Federal Leased Oil Shale Tracts in Green River Basin

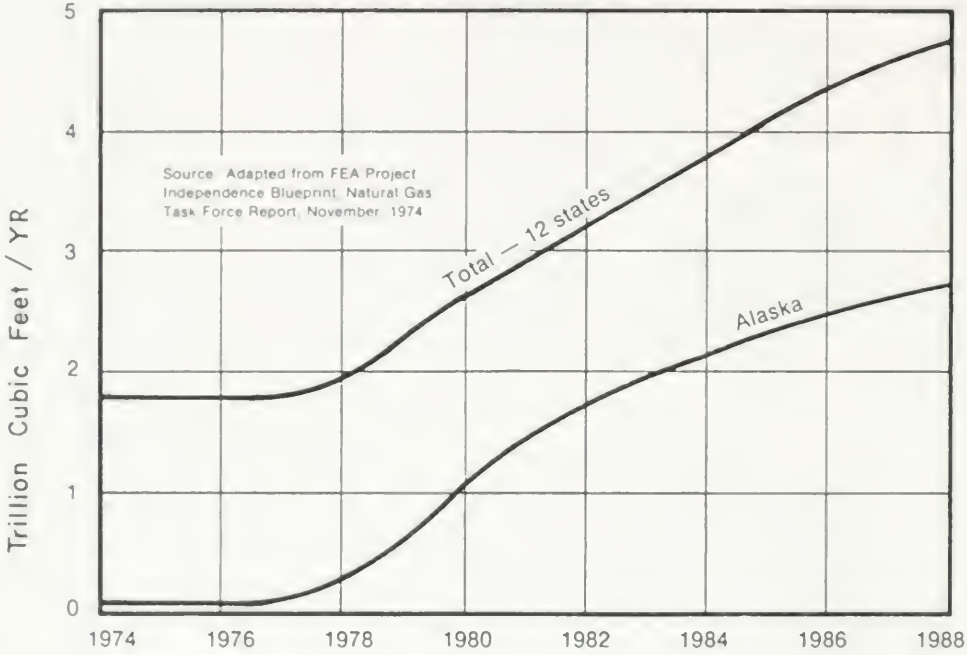
Figure 5-4

Proposed Routing of Prudhoe Bay Gas Delivery Systems



Source: Adapted from FEA 1976 Energy Outlook and from Alcan Pipeline Company application to FPC for Certificate of Public Convenience and Necessity.

Figure 5-5
Projected Marketed Natural Gas Production from WINB Member States (EXCLUDING S.E. NEW MEXICO)



as shown in Figure 5-7. This poses a severe handicap to most Western States since most of the gas sold in the West must pass through interstate systems.

The manner in which interstate gas is regulated, today, and has been regulated for the past decade, is the single most troublesome factor in sorting out the energy needs of the West. If the price were responsive to market demands, it would be used only where needed and other fuels could take its place where it is now used only because it is the cheapest fuel available.

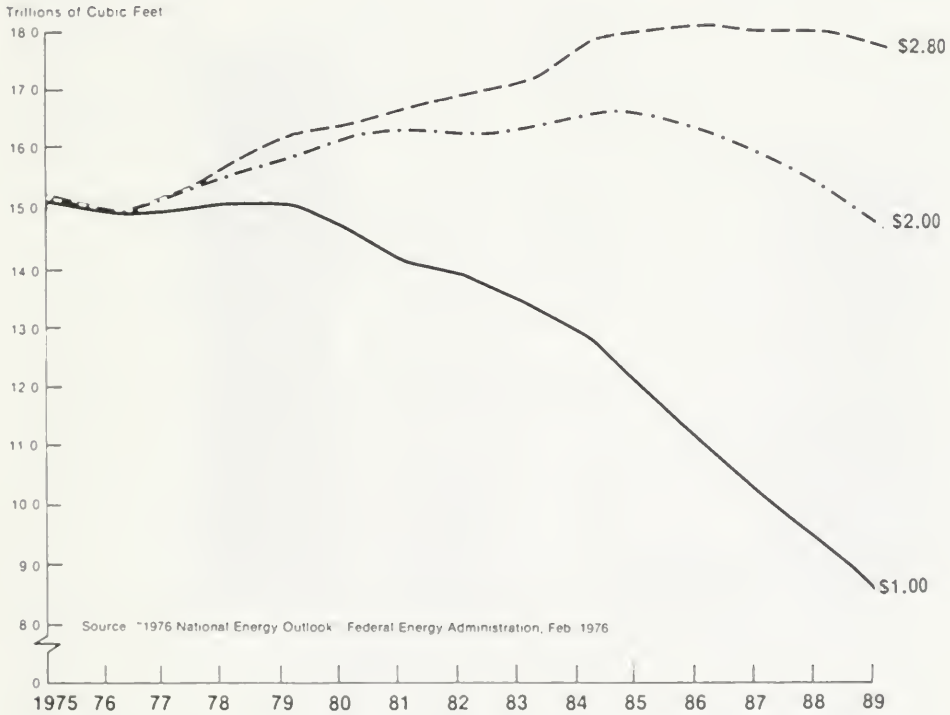
5.3 Hydroelectric

The West has long been noted for its hydroelectric potential. Even in 1976 about 46% of the generation capacity in the West is hydroelectric. With the last wave of large hydroelectric facilities being completed and with oil and gas generation decreasing, the hydroelectric percentage will peak about 1979. Thereafter, it will decrease in all states but Alaska. Even by 1986, the hydroelectric generation capacity will be about 36% according to the WSCC plan[8]. It must be noted that much of the additional hydroelectric capacity will be used for peaking purposes in the future and does not represent capacity that can be used continuously. A listing of the new, large hydroelectric additions that are scheduled for completion in the next ten years is presented in Table 5-1. The largest addition is the third powerhouse at Grand Coulee shown on the left in Figure 5-8. When fully operational in 1979 it will bring Coulee's capacity to 6,280

[8]Western Systems Coordinating Council Reply to Federal Power Commission Docket R-362, April 1, 1976.

Figure 5-6

Predicted Non-Associated Natural Gas Availability at Three Wellhead Price Scenarios



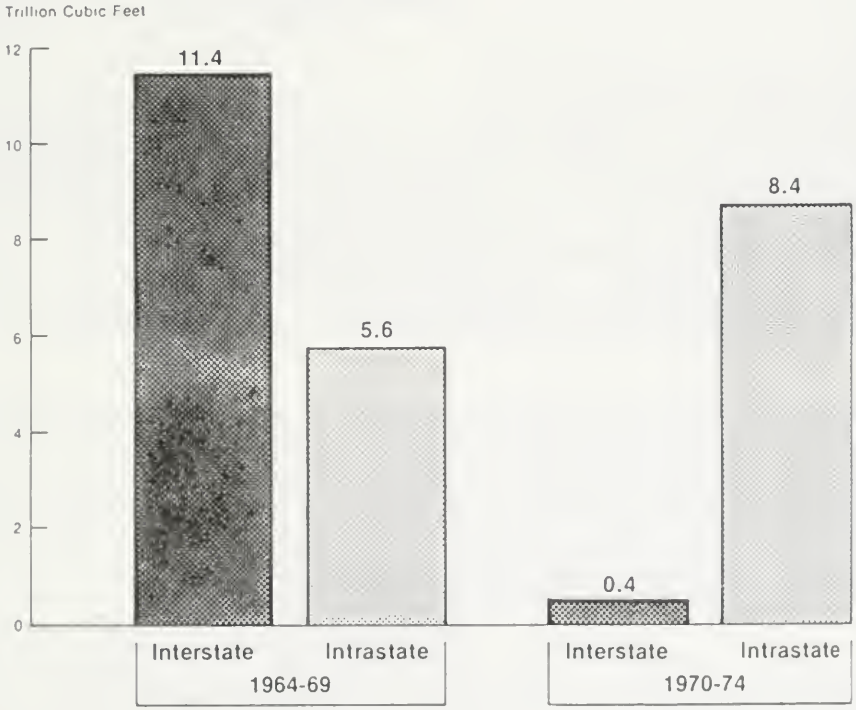
NOTE These quantities include gas used for repressurization of wells excludes tight gas

Table 5-1 Hydroelectric Resource Additions to Region (1976-1985)

	State	Name	Rating
July 1976-June 1977			
	Washington	Coulee-22	600 megawatts
	Washington	Chief Joseph	187
	Oregon	Lost Creek 1-2	56
	Wyoming	Seminoe	12
	Colorado	Morrow Pt. 3	49
	Colorado	Crystal 1	32
	Arizona	Davis	8
July 1977-June 1978			
	Washington	Coulee 22-23	1,400
	Washington	Chief Joseph 18-21	437
	Washington	Rock Island 14-18	255
	Washington	Lower Granite 4-6	455
	Washington	Little Goose 4-6	455
	Montana	Noxon Rapids 5	125
	Idaho	American Falls 1-5	66
July 1978-June 1979			
	Washington	Coulee 24	700
	Washington	Chief Joseph 22-27	656
	Washington	Rock Island 11-13	153
	Washington	Lower Monumental 4-6	455
	Washington	Ross Dam	132
	Idaho	Brownlee 5	225
	California	New Melones	300
July 1979-June 1980			
	Washington	Mayfield No. 4	40
	California	Big Creek No. 3	31
July 1980-June 1981			
	Oregon	Bonneville	74
	Utah	Cyar	9
	Utah	Dyne	33
	Utah	Sixth Water No. 1-2	40
	California	Pyramid No. 1-2	158
July 1981-June 1982			
	Oregon	Bonneville 12-17	487
	California	Cottonwood No. 1	15
July 1982-June 1983			
	Oregon	Bonneville No. 18	77
	California	Auburn	300
July 1983-June 1984			
	Montana	Libby No. 1-7	413
	California	Merchant	92
July 1984-June 1985			
	Washington	Libby No. 8	120
	California	Ward A	150
		Total	8,777 megawatts

Figure 5-7

Placement of Annual Reserve Additions of Natural Gas



Source American Gas Association, Federal Power Commission

megawatts. With greater turbine capacity in the large hydroelectric projects their value during peaking periods is enhanced and the need for "spilling water" (as shown in Figure 5-8) is reduced.

Despite an emphasis on bigness in hydroelectric projects, there is considerable opportunity for small hydroelectric generation development in Alaska and in the Northwest. Such projects may be undertaken privately rather than through the Corps. of Engineers, etc.

The state of Alaska is encouraging endorsement of the Corps of Engineers' proposal for a series of dams on the Susitna River about 60 miles north of Anchorage. Known as the Devil Canyon Dam Project, the 1,500 MW project could develop seven billion kilowatt-hours per year by 1990. The project would put Anchorage on a hydrobase rather than the natural gas turbines now in use.

5.4 Coal

The western coal fields that had been used to fire railroad locomotives for many decades found a resurgence of activity during the electric utility growth years of the 1960's. The plan has been so popular that, by 1974, the western states collectively mined 68 million tons of coal to fire utility boilers both in the West and some in the Midwest. A typical utility use is for the Jim Bridger plant near Rock Springs, Wyoming. When the three 500 MW Bridger units, in Figure 5-9, are completed in 1976 this plant will be capable of utilizing about six million tons of coal per year.

The 68 million tons mined in the West in 1974 was but 10% of the total coal mined in the U.S. as shown in Figure 5-10. The Project Independence Task Force suggests that considerably more coal be mined nationally, with a growing fraction coming from the West. By 1990 the Task Force suggests a doubling of coal mined nationally and a tripling of the coal to be mined in the West. The distribution of projected coal mining, by state, is displayed in Figure 5-11. In 1985, the combined total of coal mined in the western states would be 182 million tons, requiring an added investment of about $2 billion. Of this, 116 million tons will be required to fire the thermal-electric plants listed in Section 4. The balance, 66 million tons, would be shipped out of the region by barge, rail and pipeline. The coal-slurry pipelines proposed could cost an additional $7 billion.

The 18 million tons capacity shown in Figure 5-11, for Washington and Alaska combined, probably has only 4 million tons from Washington. The 14 million ton balance will be available for transport to either American or foreign ports from Alaska.

The coal-slurry pipelines being considered are shown in Figure 5-12. Potential sponsors for hauling coal out of the West with pipelines are listed in Table 5-2.

To be successful, most of the above pipelines will need to be granted a right of eminent domain to pass alongside and under railroads. Bitter opposition by the railroads is expected before slurry pipelines can deliver western coal to distant power plants.

Land reclamation will be an important consideration in the development of coal resources in the West. In the upper left portion of Figure 5-13 a mined area is shown that has been reclaimed. In the upper right portion is a 39 cubic yard dragline at work moving overburden prior to removal of sub-bituminous coal.

Additional coal would be required for coal gasification and coal liquefaction plants. Since no production is scheduled in either category, it is difficult to predict the impact. A cluster of four 250 million SCF gasification plants would require about one billion tons of coal over a thirty year life. When the plant is in full operation, this would amount to a rate of 33 million tons per year.

Needless to say, the coal commerce in the Rocky Mountain states is entering in a new era of expansion.

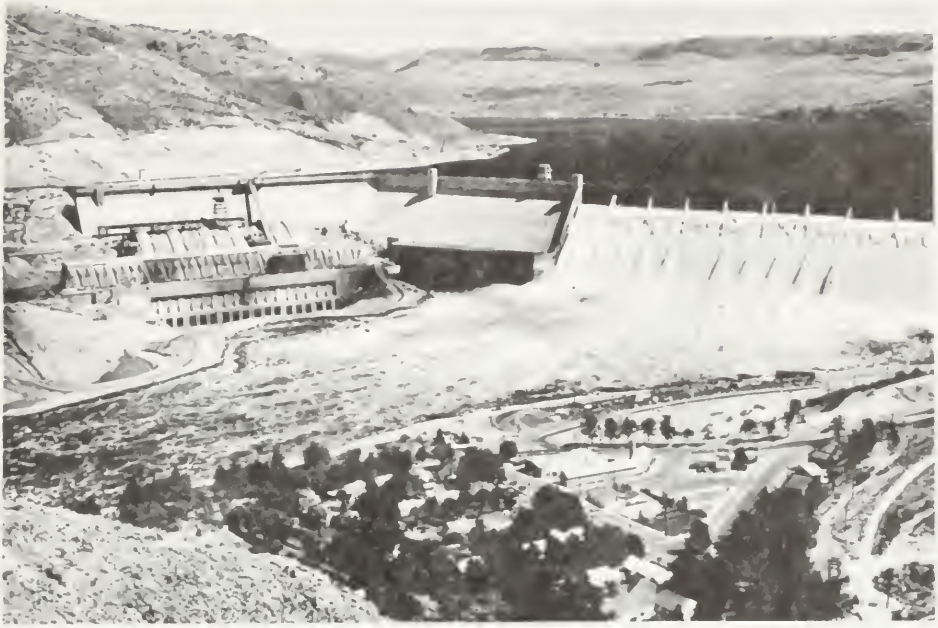


Figure 5-8 Grand Coulee Project on the Columbia River in Northern Washington.

Figure 5-9 Three units of the Bridger Coal- fired Plant near Rock Springs, Wyoming.

Figure 5-10 Coal Production Growth in the U.S. and in the West

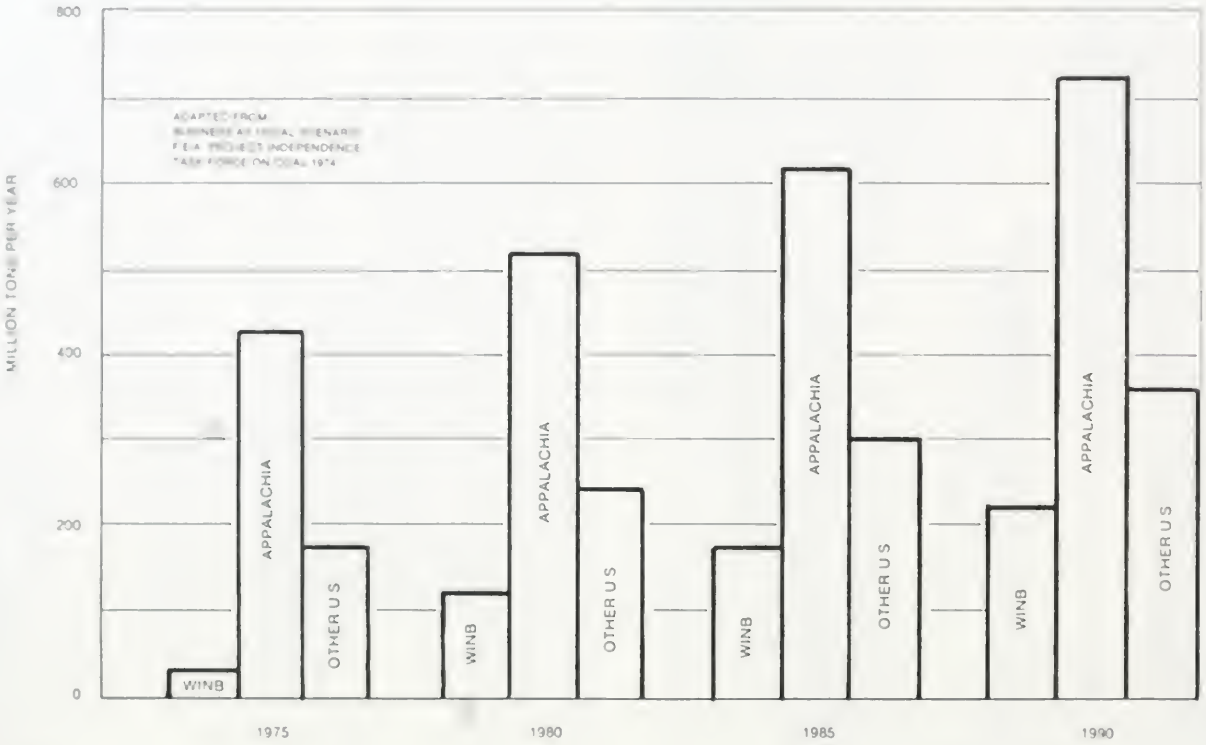
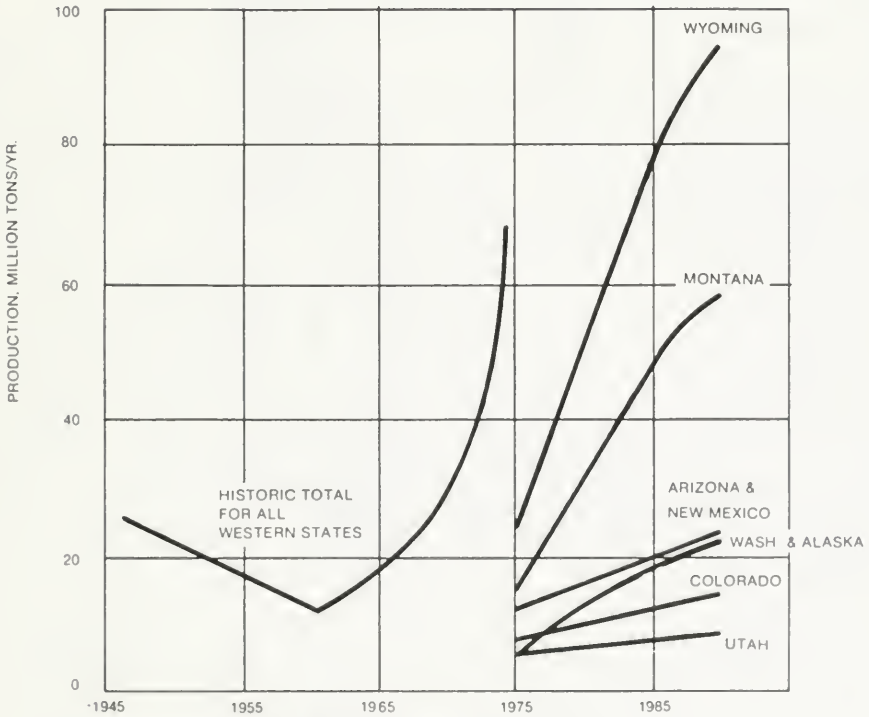


Figure 5-11

Historic and Projected Coal Production in the Western States



Adapted from U.S. Bureau of Mines statistics on bituminous coal and lignite

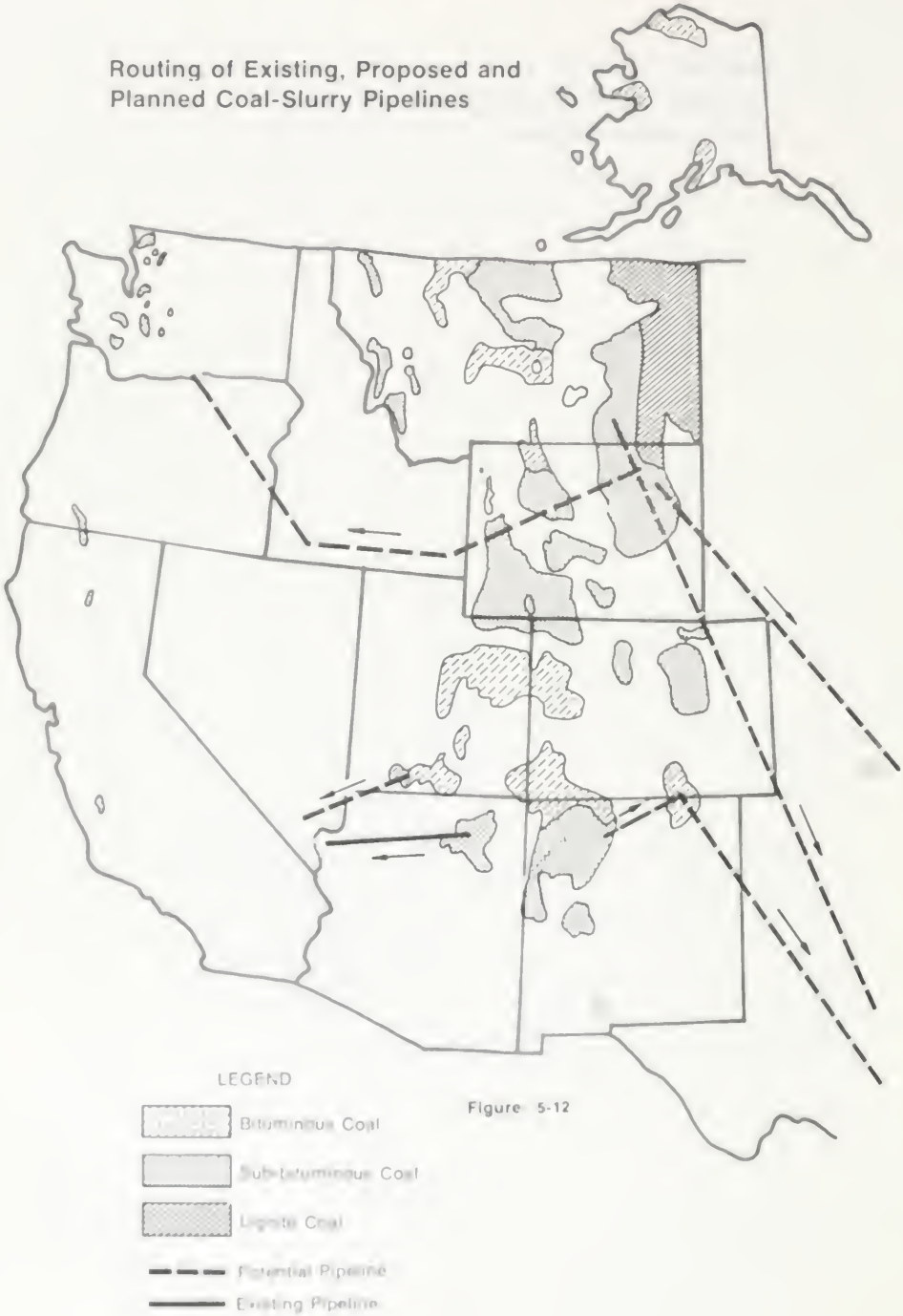

Routing of Existing, Proposed and
Planned Coal-Slurry Pipelines
LEGEND
Bituminous Coal
Sub-bituminous Coal
Lignite Coal
Potential Pipeline
Existing Pipeline

Figure 5-12

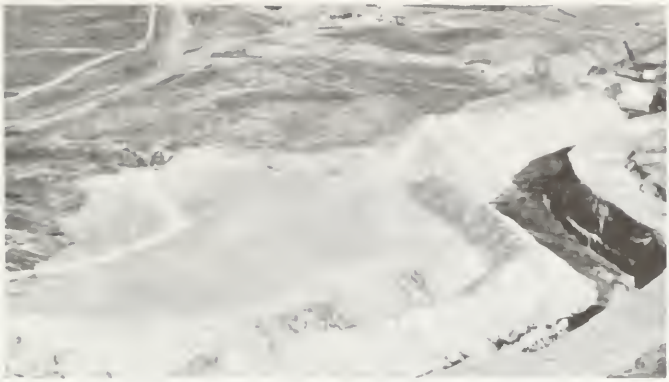


Figure 5-13 Surface Mining and Soil Reclamation Activity near Glenrock, Wyoming.

5.5 Uranium

The nuclear industry looks to the Western States to produce most all of their uranium supplies. Even though there is a current abundance of importable uranium, our nation has shown restraint in limiting imports of this valuable resource. The uranium industry in the U.S. developed long before the advent of commercial nuclear power. By 1966, the AEC had purchased over 300,000 tons of yellowcake (U_3O_8), primarily for weapons production. Since 1971, AEC purchasing has essentially terminated and the commercial nuclear industry, by 1974, was producing over 100 billion kw-hr/year as shown in Figure 5-14. Such production utilizes uranium at a rate of about 12,000 tons of U_3O_8 per year. As shown in Table 5-3, the domestic uranium industry at the end or 1974 had an installed capacity of almost 27,000 tons. However, by 1990 the domestic use of uranium is expected to total 125,000 tons of U_3O_8 per year.

Enlargement of production capacity and the resource base will be required to meet the projected requirements. It is shown in Tables 5-4 and 5-5 that the proven reserves and the potential reserves estimates have grown very slowly with the decreased exploration that has taken place since 1969. The numbers within each table are cumulative but the proven and potential reserves are additive. The reductions shown in Table 5-4 for 1974 do not indicate a decrease in the amount of uranium in the ground but rather that inflation makes less available at the costs postulated for each column in the table. It is expected that between 1973 and 1990, $10 billion will need to be invested in new mining and milling facilities of which $6 billion would be for geophysical exploration. It takes about seven years lead time from exploration to production. At the end of 1974 there was a 10-year forward reserve of U_3O_8 in the $8 per pound category. Since a reserve base is necessary for justification of the investment in mines and mills and for contracting for sale of the products, a new proven reserve base of between 700,000 and 950,000 tons is sought to cover the $10 billion dollar investment noted above. Much of the exploratory expense will be to better identify deposits previously categorized as potential resources and will be in the shaded regions shown in Figure 5-15.

The result of additional exploration will undoubtedly consider less concentrated deposits some of which may cost as much as $30 per pound to recover. Traditional uranium-bearing sandstones in the West are unlikely to ever require more than $30 per pound for recovery, based on 1974 dollars. The next step would be to recover uranium from other host rock formations such as Chattanooga shale at a cost of between $30 and $90 per pound, or go to a thorium fuel cycle or to breeder reactors. Most of the uranium production expansion is apparently expected to occur in Wyoming since that is where most of the exploratory work is being conducted, as shown in Table 5-6. Although the uranium resource base will undoubtedly expand, the discoveries will be increasingly difficult and expensive. A record amount of exploratory drilling is expected in 1976. To meet projected needs, at reasonable costs, the planned $6 billion geophysical exploration must proceed unimpeded.

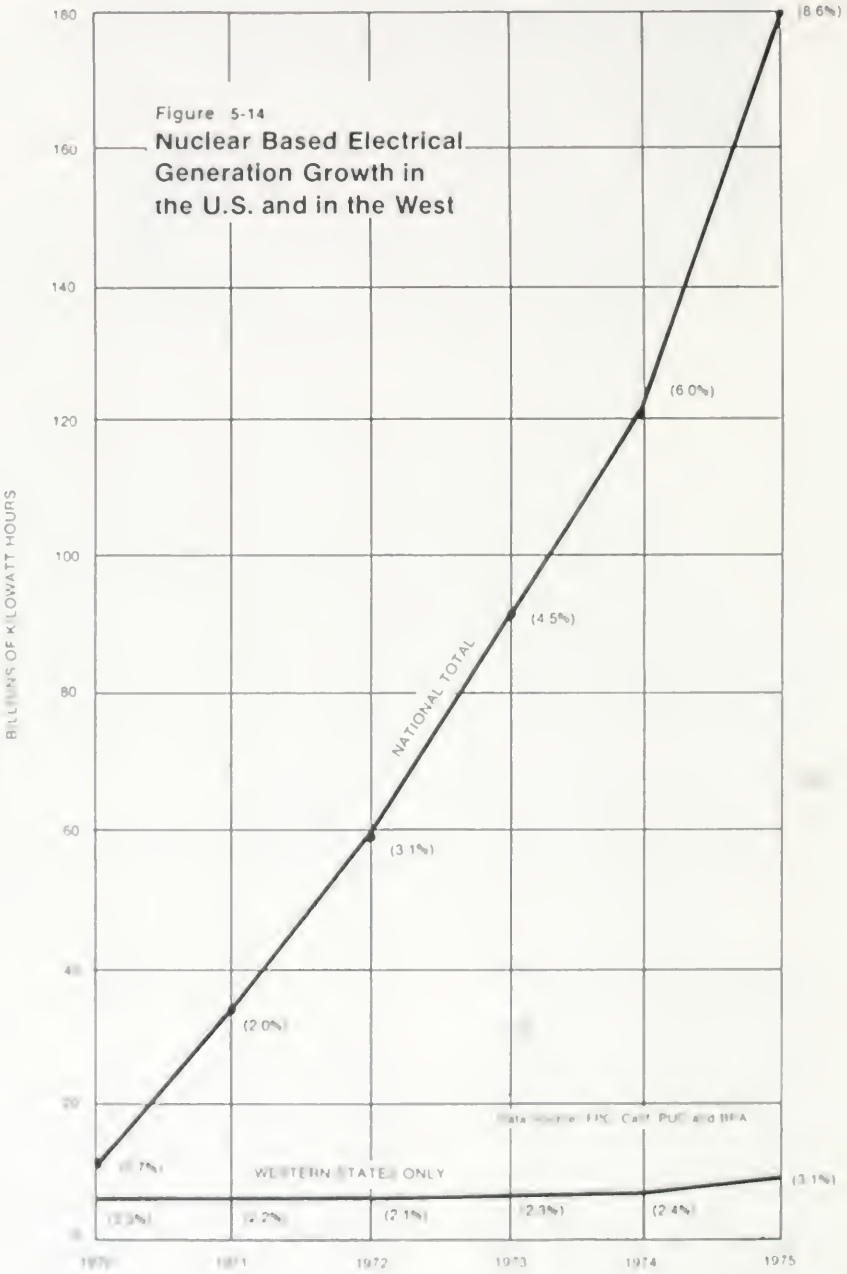


Figure 5-14
Nuclear Based Electrical Generation Growth in the U.S. and in the West
BILLIONS OF KILOWATT HOURS
NATIONAL TOTAL
WESTERN STATES ONLY
(8.6%)
(6.0%)
(4.5%)
(3.1%)
(2.0%)
(3.1%)
(2.4%)
(2.3%)
(2.1%)
(2.2%)
1972
1973
1974
1975

Table 5-2
Potential Coal-Slurry Pipelines Originating in WINB Member States

Sponsor	Routing	Capacity, millions tons/year
Energy Transportation Systems, Inc.	Wyoming to Arkansas	25
Houston Natural Gas Company	Colorado to Texas	9
Texas Eastern Transmission Company	Montana to Texas	25
Nevada Power Company	Utah to Nevada	10
Gulf Interstate Engineering Company	Wyoming to Oregon	10
Southern California Edison	Arizona to Nevada	5
	Total	84

Table 5-3

URANIUM ORE PROCESSING PLANTS IN U.S.
(as of December 30, 1974)

	Nominal Capacity (tons ore per day)	National Capacity %
Colorado	1,750	7
New Mexico	13,500	50
Texas	1,750	7
Utah	1,700	6
Washington	400	2
Wyoming	7,550	28
	26,650	100

Source: "Statistical Data of the Uranium Industry" Energy Research and Development Administration, January 1, 1975.

Table 5-4

HISTORIC ESTIMATES OF URANIUM PROVEN RESERVES WITHIN THE U.S.A.
(tons U_3O_8)

Year End	$8/lb.	$10/lb.	$15/lb.	$30/lb.
1966	141,000	200,000		
1967	148,000	190,000	248,000	
1968	161,000	200,000	265,000	
1969	204,000	250,000	317,000	
1970	246,000	300,000	391,000	
1971	273,000	333,000	520,000	
1972	273,000	337,000	520,000	
1973	277,000	340,000	520,000	634,000
1974	200,000	315,000	420,000	600,000
1975	200,000	270,000	430,000	640,000

Source: "Statistical Data of the Uranium Industry" Energy Research and Development Administration, January 1, 1976, GJO-100 (76).

Table 5-5

POTENTIAL RESOURCE ESTIMATES FOR URANIUM WITHIN THE U.S.A.
(tons U_3O_8)

Year End	$8/lb.	$10/lb.	$15/lb.	$30/lb.
1966		325,000	525,000	665,000
1967	245,000	350,000	570,000	1,000,000
1969	385,000	600,000	960,000	1,600,000
1970	490,000	680,000	1,040,000	1,600,000
1971	460,000	650,000	1,000,000	1,600,000
1972	450,000	700,000	1,000,000	1,600,000
1973	450,000	700,000	1,000,000	1,600,000

Source: "Statistical Data of the Uranium Industry" Energy Research and Development Administration, January 1, 1975.

Table 5-6

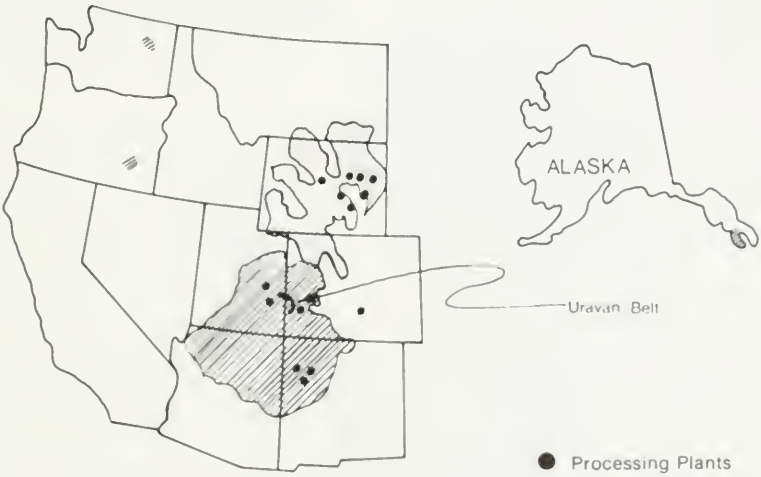
DISTRIBUTION OF 1974 EXPLORATORY DRILLING FOR URANIUM IN U.S.

State	Drilling (feet)	% Total
Wyoming	12,054,000	46.4
New Mexico	5,698,000	21.9
Texas	3,316,000	12.8
Utah	1,538,000	5.9
Colorado	1,362,000	5.2
Balance*	2,032,000	7.8
	26,000,000	
		100.0

*Includes Arizona, California, Idaho, Nevada, North Dakota, South Dakota, Oregon, Utah, Pennsylvania and Washington.

Source: "Statistical Data of the Uranium Industry" Energy Research and Development Administration, January 1, 1976.

Principal Uranium Producing Areas for 87 Percent of U.S. Production and Processing Plants



NOTE Some production has occurred in Alaska, Oregon and Washington.

Figure 5-15

5.6 Geothermal

Geologic irregularities in the West provide access to geothermal reservoirs of hot water and steam at reasonable depths. There have been many known geothermal areas (KGA's) in the West detectable by surface manifestations. The Department of Interior has been in the process of leasing the KGA's since the Bible Act of 1971. The KGA's and other significant activities are within the shaded area noted in Figure 5-16. Only one of the new leases has yet resulted in the generation of electrical power. This one is in the Imperial Valley in California where 10 MW is being generated.

Geologists have learned to recognize the faulting in the earth's crust that can lead them to relatively easy access to geothermal energy. Since 1974, major geothermal finds other than the long-known KGA's include wells near: Brigham City, Utah; Raft River, Idaho; and Milar, Utah. The field near Milar, Utah has been described by USGS as being of the same magnitude as the famous Geysers reservoir in northern California.

The Geysers field is now producing 500 MW on a fairly sustained basis for Pacific Gas & Electric Co. Electrical energy produced at this field is competive with alternate fossil fuel costs and is now competitive with even nuclear energy.

A fast developing plan near Portland, Oregon involves moving geothermal waters off Mt. Hood into Portland for district heating. The natural gas utility in Portland is hard-pressed for future gas resources and is a principal sponsor of the project. Exploratory work to measure water temperatures, purity and flow rate are expected to begin in 1976.

Potential Geothermal Fields in the West (with Activities noted)

Figure 5-16

5.7 Developing Technologies

Solar energy activities in the West have been generally limited to heating and cooling functions. This effort is well placed and can save much of the comfort heating and cooling fuels requirement, which is substantial. Earliest applications are expected in regions with a mild climate and a high solar incidence. Figure 5-17 shows that the highest solar incidence is in the Southwest, especially Arizona. Greater implementation of solar heating systems is expected to follow the increases in in natural gas and electrical rates. ERDA is also financing efforts to convert solar energy into electrical energy with a goal of achieving capital costs below $2,000/kw.[9]

Installation of wind power generators is scheduled by the Energy Research and Development Administration (ERDA) for FY 1977.[9] The locations are yet to be announced but at least one is expected in the West.

With continued funding, commercial deployment of breeder reactor technology is expected by 1986. The next breeder reactor to become operational in the U.S. is at the Hanford Reservation in S.E. Washington. The 300 MW Fast Flux Test Facility is expected to be completed by 1979 at a total cost close to one billion dollars.

Studies of laser-matter interaction phenomena and advances in laser technology permitted the achievement of a major program milestone in 1974. As more powerful lasers become available, significant fusion yield is expected to be achieved, in 1979, followed by a "scientific break-even" in 1982 and a "net energy gain" by the mid-1980's. Based on success in achieving the above schedule, an operational test system could be deployed by the late 1980's and a demonstration power plant by the mid-1990's. Despite the significant progress being made in fusion research, the western utilities have no basis to depend on energy from fusion within the current century.

6.0 Factors Impacting on Consumption

6.1 Conservation

Energy conservation has been tested as a method for reducing the growing demands for energy. Voluntary efforts appear to have netted about a 10% reduction, at best. Legislative efforts have been unpopular but have been readied for emergencies when quick mandatory action is required. The extent of reduction would be set to meet the needs of the emergency. Industry would be the first to suffer with natural gas curtailments.

There are numerous conservation efforts activated in the various member states some of which are descirbed in Section 8.0.

6.2 Economy

The recession of 1975 proved that a depressed economy can have a significant effect on the energy demands. Productivity and energy consumption are known to have a close correlation. The primary energy reductions during 1975 were industrial loads; however, residential loads failed to grow at historic rates. Even though total energy needs may decrease for the next few years, there is no reason to expect a decrease in electrical loads. Nor is the electric load growth in the East much of an indicator of the electric load growth in the West. Statistics available on 1974[10] show that the electric loads in the WINB region grew 0.7% while the loads in the total nation decreased 0.3%. In the industrial sector the growth rate in the West was 3.5% while nationally the growth rate was 0.3%.

---

[9] ERDA 76-1 "A National Plan for Energy Research, Development & Demonstration: Creating Energy Choices for the Future-1976, Volume 1: The Plan.

[10] "Electric Power Statistics" Federal Power Commission December, 1974

The greatest single factor to affect demand on all forms of energy appears to be price. Although this is not a surprising observation, the prices on most fuel commodities have only recently risen to a point that the buyers are beginning to make new value judgments. When the artificial economies are removed from regulated natural gas prices, there can be a sound basis for rearranging dependence on alternate fuels. At that time, the growth rate will drop for natural gas as it has for oil. The investments in heat pumps and solar collection systems can then be better justified and the use of solid fuels may return to a prominent place in our economy.

The net effect of an uncertain economy has caused energy forecasters to predict a very slow growth rate for oil and gas, a moderate growth rate for electrical power and a resultant high growth rate for coal development. In the two years since the 1974 WINB Energy Study, the demand for coal has shown signs of strengthening in the long term. During the same time period, the price of uranium has more than doubled and the fuel cycle is still open-ended.

Although utilities seem to favor the operation and economies of nuclear plants, it is an expensive task to build a nuclear plant with today's regulatory constraints and high interest rates. A recent estimate[11] on the capital cost of nuclear and coal-fired plants showed nuclear to cost $1,000 per installed kilowatt and the coal plant to be $930/KW. The generation costs of the nuclear plant analyzed were 35 mils/KW-hr compared with 39 mils/KW-hr for the coal-fired plant. It now takes almost eleven (11) years to complete a nuclear project. The escalation and interest during such a long construction project can amount to $380 million for a 1,000 MW plant. This is more than the original cost estimate of the Trojan plant which appears in Figure 4-7 of this report. Consequently, the demand for nuclear plants has not developed in the West at the same rate as expected two years ago.

The above March 1976 economic analysis for Idaho assesses the extent and the impact of the price escalations that have followed the oil embargo. The 6 mill/KW-hr power th that was expected from thermal electric plants just six years ago is going to be more like 36 mills/KW-hr by 1986. This increase is due not only to higher capital investment and longer escalation periods, but higher fuel prices as well. The costs for new thermal electric generation are expected to rise sixfold from 1974-1986. As a result of these increases, very significant increases can be expected to the average electrical consumer.

Figure 5-17

Solar Insolation Contours in the Southwest

[a]Figures give solar heat in Btu/ft^2 per average day.

Source AEC 1974

[11]"The Economics of Coal vs. Nuclear for a Power Plant near Boise, Idaho," Office of Nuclear Energy Development, Idaho Nuclear Energy Commission, March, 1976.

7.0 Factors Impacting on Production

A variety of energy resources is being considered for meeting future energy needs. Coal and nuclear resources have already been discussed and are limited to electrical production. Oil and natural gas are clearly resource limited. The rate at which oil and gas are being depleted prompts efforts towards greater electrification and to development of alternate energy sources.

Geothermal energy is one alternate energy source that is finding favor and is given a chance to make a significant contribution with the help of a federal loan program. By 1986, about 1.3% of our electrical production in the West is expected to originate from geothermal sources, compared with 13% from nuclear.

Other developing sources of energy such as synthetic fuels, solar-electric, breeders and fusion will still be too developmental, in 1985, to be able to offer significant commercial production. Increased funding levels for the above developing sources will not assist significant energy input in the term of the study period (1975-1985), but may shorten the day when they can be useful.

It is no longer possible to conclude that energy sources can be produced and shipped from one location simply because they are economic and needed at another location. There is a long list of frustrations and disappointments in trying to achieve national energy independence with a multitude of restrictive federal regulations. Such regulations and recourse to the courts for judgment are probably among the largest and most uncertain factors impacting on production of energy from resources in the West.

Efforts to transport natural gas from Alaska to the "lower-48" are an example of the flagellation not only permitted but required under existing federal laws. Other examples are legion but only a single case with natural gas will be examined here.

For more than a decade, natural gas has been a surplus fuel commodity in Alaska. The long established process of liquefying the natural gas was examined by American industry to create LNG, a liquid fuel that can be shipped in an insulated ship. A market for LNG has been available in the "lower-48", as well as other parts in the world. However, because of the Jones Act, of 1920, the LNG can only be transported in American ships for which there are none suited. As a consequence the LNG traffic from Alaska has been to Japan rather than to the "lower-48", where natural gas curtailments have become increasingly common. At least one port in the Northwest is continuing to build LNG receiving facilities. And, at least one gas utility in the Northwest has offered to build such a ship but the FPC will not allow such action until various other possibilities for Prudhoe Bay gas transport have been approved. The earliest determination on alternate systems by FPC is expected in 1977. If approved, the earliest date that gas can be shipped to the "lower-48" would be about 1982.

Meanwhile, the global demand for fertilizer has sufficiently developed that one manufacturer of urea has been prompted to build the world's largest natural gas-to-urea plant on Alaska's Kenai Peninsula. The plant is expected to be operational, by late 1977, and use 140 billion cubic feet of natural gas annually. The combined Oregon and Washington natural gas deficit in 1974 was 270 billion cubic feet. Additional surplus gas is still available on the Kenai Peninsula and may be the Northwest's only hope since some pipeline proposals bypass the Northwest altogether.

Other primary case histories involve suspension of federal lands for coal leasing difficulties in releasing federal lands for geothermal exploration and development, market uncertainties for oil from shale and tar sands and continued price controls on interstate gas. All will impact on production of energy resources in the West.

8.0 Contingency Planning and Conservation Efforts in Member States

The three usual reasons for energy conservation are that

- --it is more expedient than developing new sources
- --it is less expensive than new supplies
- --it can be done without federal restrictions

With a multi-trillion dollar national program of energy independence that will take several decades to complete, the expediency and savings of energy conservation need to be important considerations. In a resolution of the National Governors Conference in February 1975, it was concluded that: "A conservation program of massive proportions must be the central focus of our nation's short-range energy management program."

The federal government has encouraged each state to develop an energy conservation plan with the Energy Policy and Conservation Act. The Act provides for $5 million in planning grants for FY 1976 and $23 million, in FY 77, to develop a plan that would reduce the consumption of energy at least 5% in each state. Of the total, $4 to 5 million would be available to the Western States.

Since April 1975, the National Governors Conference staff has been working with FEA to develop and implement the above conservation program. Each WINB member state has now submitted a "State Plan". The plans establish consistent measurement of energy resource consumption, systematic communication, and coordination of the states and FEA on energy conservation efforts.

When implemented, about January 1977, the state programs will collect energy use data, project future energy use trends, identify and analyze potential conservation actions, set conservation goals, and announce implementation of the action plan through the Governor's offices. The states will monitor, evaluate and modify the plan as required. The FEA will serve as a focal point for coordinating all federal agencies with regard to energy conservation and will provide a network for the transfer of information to and among the States. The Western Governors Conference (WGC) established a special task force to formulate a region-wide energy ploicy statement. In 1974, the WGC adopted the energy policy statement shown in Appendix B.

The same set of principles calls for adoption of a long-range policy that encourages domestic self-sufficiency in the production of energy. In securing "an adequate supply of energy" the nation's Governors have called for maintainence of environmental standards "to the maximum extent feasible". The governors note that "supply and distribution systems in the energy field are so complex that no region or community can shirk its responsibility without imposing unfair burdens on others. If a fair share of the energy is demanded, then a fair share on the responsibility on the supply side must be assumed." The governors call for added capacity to be "located most usefully for that State and the region in which it exists" with a conviction that there is no need for federal preemption on siting.

The National Governors Conference (NGC) have established[12] some guiding principles with regard to energy availability, natural resource management and energy conservation. Among the principles is a recognition that nonreplenishable energy resources must no longer be wasted. This includes not only the fuels required to generate electricity but for transportation, comfort heating, etc. Recognition is made that conservation of electrical energy is directly related to conservation of finite fresh water supplies. Especially noteworthy are the Governor's expressed interest in alteration of the utility rate structure and the gathering public support for mass transit systems.

Energy conservation measures that would be specifically considered in the State/Federal conservation program are listed in Table 8-1.

---

[12]"National Governor's Conference Energy Policy", adopted at June 1975 Annual Meeting

Table 8-1
Energy Conservation Measures to be Considered in State/Federal Conservation Program

- New standards for energy efficiency in residential and commercial buildings;
- Restructuring of utility rates to include peak-load pricing and other load management techniques;
- Establishing incentives or removing disincentives in taxing to encourage upgrading of homes for technical energy efficiency;
- Sponsoring and extending preferential treatment to car and vanpools (require automatic coverage by auto insurance, allow exchange of money, designate special lanes, establish financial disincentives for parking);
- Enacting laws and establishing regulations to improve traffic flow (right turn on red light);
- Increasing efforts to enforce the 55 mph speed limit;
- Increasing taxes on energy fuels;
- Adopting systematic energy management programs in State-operated buildings and auto fleets, including changes in state procurement policy to reflect life-cycle costing;
- Implementing programs to collect and use waste oil;
- Encouraging use of solid waste as a fuel source;
- Implementing weatherization programs to insulate existing homes occupied by the poor;
- Construction of bicycle pathways and secure storage racks;
- Improving public transportation;
- Sponsoring voluntary programs, such as "outreach" to provide lighting guidelines to commercial building owners and tenants;
- Technical assistance programs for residential retrofit;
- Mounting public information campaigns to homeowners, automobile drivers, building owners, and industrial users;
- Requiring that energy consumption education be incorporated into primary, secondary, and higher education curricula;
- Conducting youth programs;
- Revising professional certification procedures to require training in energy conservation;
- Establishing an Energy Conservation Month;

The program will include a cost/benefit analysis for the above actions, indicate priorities and attempt to set goals for 1977, 1980 and 1985. The FEA will be available for technical assistance and for obtaining assistance from other federal agencies.

At the 1975 National Governors Conference, "The Governors pledge not only to provide leadership in the energy conservation effort but also to enlist the cooperation and support of their legislatures. They will also work with private individuals and organizations as well as with officials of local governments."

9.0 Actions Open to Member States

There are a wide range of actions open to state governments for securing an adequate and reliable source of energy for its present and future citizens.

Some of the actions include:

1) supporting research and development at state universities on new energy technologies,
2) supporting state and regional energy assessments, impacts and long-range planning,
3) encouraging conservation programs at all levels
4) restructuring the utility rates to encourage less consumption and a shift to off-peak periods,
5) provide incentives to energy producing industries that do not depend on oil and natural gas supplies,
6) provide vocational training to technicians for installing insulation, alternate energy systems and programing ventilation systems,
7) strengthening energy education at all levels and especially in the school systems,
8) providing for an adequate number of power plant sites.

A fundamental energy conservation package has been offered to all states by FEA for examining and implementing on energy conservation program. All member states have responded to the FEA and appear ready to participate in the State/Federal conservation program described in section 8.0.

There are several states, including Alaska that are conducting their own energy assessments. Alaska is conducting an ERDA funded study to survey which Alaskan energy resources are potentially recoverable by the year 2000. The Alaskan study will identify needed technology for recovery storage, transportation and use of various energy sources and will address the factors of lead time, environmental impact, socioeconomic impact and legal constraints. In addition to a quantification of oil and gas resources the assessment will include geothermal, hydroelectric and uranium resources.

Of the twelve WINB member states, seven (Arizona, California, Oregon, Montana, Nevada, Washington and Wyoming) have siting legislation enacted for new central station power plants. Those states with siting legislation generally call upon their natural resource agencies to evaluate the potential impact before approving the sites. Federal siting legislation does not appear warranted since the states have shown that they can do an adequate evaluation.

The individual states must take responsible action in assisting in the routing of pipelines and transmission lines into and through their respective states. The need for a strong technical regulatory staff within state governments continues to grow to meet the energy needs of the states without unnecessary abuse to the natural environment.

With collective analysis and planning by the twelve western states, the region can handily accomodate the energy producing industries necessary for the region to become a net energy producer.

10.0 Appendix

Appendix A

Conversion factors -

Natural Gas	1,075 BTU per cubic foot
Crude Oil	5,800,000 BTU per barrel
Oil Shale	5,800,000 BTU per barrel of recovered oil
Residual fuel oil	6,300,000 BTU per barrel
Western coal (typical)	20,000,000 BTU per short ton
Wood	216,000 BTU per cubic foot
Kilowatt hour (kwh)	3,412 BTU per kwh (theoretical) 9,895 BTU per kwh (at 34.5% efficiency) .0017 Barrels per kwh

Appendix B

Western Governors' Conference 1974 Statement on Western Regional Energy Policy

Preamble

Presently prevailing world energy policies are based principally on an expectation of continuous expansion of the use of non-renewable resources, particularly fossil fuels. Today it is American society's general opinion and hope that the energy crisis will be resolved by discovery and development of even more non-renewable resources than are now known to exist.

While it would be many years before all the world's non-renewable resources could be consumed by present economic systems, logic forces two conclusions that pose a distinct threat to society's hope.

One is that it is becoming too expensive, from the standpoint of "net energy," to develop and put into the system certain non-renewable resources. So much energy is used by man and his machines to produce energy, that a net loss might be incurred. Consideration should be given, as an example, to whether construction of a natural gas pipeline from the Polar Cap to the United States might not consume more petroleum-based energy than the energy that would ultimately flow from the new source. Use of petroleum products to provide small--or no--net gain should be avoided; instead, non-renewable energy resources should be dedicated to projects that will assure, or might assure, a stable energy supply from such sources as the sun, wind, underground heat reservoirs, and nuclear fusion.

A second conclusion is that the more a society increases energy use in relation to its availability, the more costly energy becomes. Present economic conditions demonstrate that as easily recoverable world reserves are depleted, and our demand and dependence upon fossil fuels increase, the monetary value of the remaining reserves is sharply escalated. The projected internal requirements of producing countries will reduce the available fossil fuel reserves to purchasing countries. More and more will be kept for internal developments.

An energy policy that does not take these conclusions into consideration will promote steadily increasing economic instability. Public opinion surveys show that the "energy crisis" is uppermost in the mids of Americans, who are anxious that the flow of energy catch up with demand. But as energy shortages worsen, the principal impact will become, and remain, the economic problem that is so steadily advancing.

Responsible policy requires development of an orderly transition to a society with stable energy income processes, and that promotes the conservation and recycling of non-renewable resources. In other words, we no longer can opt for wasteful energy useage simply because of short-range economic advantage.

The following statements of principle are adopted as recommendations of the Western Governors' Conference to respond to the necessity for a self-stabilizing system of energy production and consumption:

1. Immediate and permanent energy and non-renewable materials conservation programs should be instituted in every sector of society. The States comprising the Western Governors' Conference take the position that conservation must be practiced by all the States of the Union, but also encourage unilateral and innovative actions that might offer new ways for other to make the transition from present wasteful and inefficient energy consumption practices.

2. The States of the Western Governors' Conference will work cooperatively to promote the best use of all our social, economic and environmental systems in an effort to maintain and preserve the things we desire most from our lives and our culture.

3. To promote mutual trust, the States comprising the Western Governors' Conference recommend that all States be equitably served from existing energy sources, commensurate with need, regardless of whether they are producing or consuming States. Further, the Western States agree to insure--through legislative and/or Executive action, if necessary--the most efficient uses of all energy consumed.

4. Each State that is a potential producer of energy in any of its forms is expected to make its contribution to the national need. Experience has shown that energy can be produced in many instances with minimal effect on the environment and esthetics. States should not deny production of energy to rely upon the resources and environments of other States, unless such production produces irretrievable environmental, social or economic degradation.

5. All producing States which are serving as a source of primary energy or as a source of natural energy forms, such as fossil fuels, are entitled to a fair market value, or other comparable consideration, for their products.

6. Each State should develop priorities for energy use. These priorities should be essentially uniform, except where one or more is totally inconsistent with an individual State's need or character.

7. In an effort to avoid the early depletion of domestic reserves of non-renewable energy resources, the national government should encourage purchase of supplies made available elsewhere in the world, not in lieu of domestic production but complementary to it. Energy independence conceivably could be achieved by 1980 (the President's stated goal), but the price also conceivably could be strategic energy and economic imbalances among the have-not and competing nations.

8. Incentives to encourage energy conservation, recycling systems, increased attention to energy development, and storage of fossil fuels should be offered by the Federal government and, to the extent possible, by the States unilaterally.

9. It is the position of the Western Governors' Conference that the free market system is generally best fitted to regulate prices. However, when the system is temporarily out of balance, as in the case of energy supply and demand, some government regulation is required. At the present time, regulations should be adopted to assist the free market system to adjust in the transition from energy surplus to energy shortage.

10. An increasing amount of fossil fuels and non-renewable materials available to the United States should be used to develop diversified self-repeating energy income sources--such as solar energy systems--and recycling processes for every type of non-renewable material.

11. The Western States agree to coordinate publicly-sponsored research activities and, to the extent possible, private research activities, designed to demonstrate methods of conservation, more efficient uses of energy, increased production from existing sources, and discovery and development of new sources of energy. Research activities presently under way or contemplated should be made known to and, as possible, coordinated by the Governors, or their representatives, to avoid fragmentation of effort.

12. A national energy research program, properly organized and managed, should be created to develop better exploration, recovery and processing methods of conventional energy sources, and to develop new energy sources within acceptable environmental parameters. This program must be massively financed and immediately implemented as soon thereafter as it is organizationally prepared. The States comprising the Western Governors' Conference will seek to utilize existing institutions with the demonstrated capacity for this type of research, and urge that the Federal government adopt a similar policy as opposed to creation of new research organizations.

13. By adoption of this statement, the Governors direct the Staff Advisory Committee of the Western Governors' Conference to coordinate creation and implementation of information-gathering to improve the decision-making systems for government, industry, commerce and residential users of energy in an effort to integrate and stabilize energy, material, environmental and economic cycles, thus insuring the stable continuation of each of these essential systems.

14. The Western Governors' Conference is convinced that no sensible state, regional or national energy policy can be arrived at without solid factual statistical data on several basic factors: supply, demand, reserves, production, and distribution. The Western States believe the need can best be met by the availability of statistical data developed from an impartial governmental official source derived from independently generated original data. We therefore support the creation of a federal bureau of energy information.

15. Governors, legislators, other levels of government, business and industry, and consumers must have an opportunity to participate in preparation of national energy policies. The Governors ask that all persons and interested agencies be given the opportunity to participate in development of these policies, rather than being called upon solely to react to the content of a policy drafted by the Administration and/or the Congress. The Western Regional Policy and the policy of each State in the region will be subject to the same opportunities for comment by residents of the region and the individual States.

#

Approved March 6, 1974 at a called meeting of the Western Governors' Conference.

Appendix C

Glossary

aerobic: occurring in the presence of free oxygen. An aerobic organism requires free oxygen for respiration.

agglomeration: the aggregation of small particles of a solid into larger clumps. Many coals exude a sticky, tar-like substance when they are heated at low temperatures. This substance makes small coal particles gather into larger lumps which impede handling of the coal and cause it to react unevenly in gasifiers.

alpha rays: radiation emitted during some nuclear reactions and consisting of charged particles which are composed of two protons and two neutrons. An alpha particle is identical with the nucleus of a helium atom.

alternating current (ac): an electric current that reverses its direction of flow periodically (see frequency) as contrasted to direct current.

ambient temperature: temperature of the surrounding cooling medium, such as gas or liquid, which comes into contact with the heated parts of the apparatus.

anaerobic digestion: the use of microorganisms that can live only in the absence of oxygen to decompose organic materials into components that are more valuable or more easily disposed of. The chief use of anaerobic digestion now is reduction of the volume of sewage sludge, but it could also be used for the production of synthetic natural gas from organic wastes or from algae.

anthracite: a hard, black, lustrous coal that burns efficiently and is therefore valued for its heating quality.

asphalt: a semi-solid mixture of hydrocarbons, usually formed as a result of evaporation of volatile constituents of petroleum.

This glossary was prepared by the Oregon State University Office of Energy Research and Development, in July 1975, to provide the public with a useful tool with which to gain an understanding of the field of energy. The guide is intended for persons that are not specialists in the subject and therefore some definitions may not be precise. It is reprinted here by WINB with the belief that non-specialists can best contribute to the development of energy policies when the terms of the trade are understood and used.

atomic nucleus: the positively charged core of an atom, with which is associated almost the entire atomic mass but only a minute fraction of the atomic volume.

average life (mean life): the average of the individual lives of all the atoms of a particular radioactive substance. It is 1.414 times the radioactive half-life of the substance.

barrel: a liquid volume measure equal to 42 gallons, commonly used in expressing quantities of petroleum and petroleum products.

baseload: the minimum load of a utility (electric or gas) over a given period of time. Units in baseload service are operated in full capacity all the time.

binary cycle: an energy recovery system which controls the separate fluids in parallel systems. The purpose of a binary cycle is to obtain higher efficiencies from the energy source.

bioconversion: a general term describing the conversion of one form of energy into another by plants or microorganisms. Synthesis of organic compounds from carbon dioxide by plants is bioconversion of solar energy into stored chemical energy. Similarly, digestion of solid wastes or sewage sludge by microorganisms to form methane is bioconversion of one form of stored chemical energy into another, more useful form.

biomass: the total mass (or weight) of all organisms in a habitat or area.

biosphere: the zone of air, land, and water at the surface of the earth that is occupied by living organisms.

bituminous coal: soft coal; coal that is high in carbonaceous a and volatile matter. When volatile matter is removed from bituminous coal by heating in the absence of air, the coal becomes coke.

breeder: a nuclear reactor that produces more fuel than it consumes. Breeding is possible because of two facts of nuclear physics: (1) Fission of atomic nuclei produces more than two neutrons for each nucleus undergoing reaction. In simplified terms, then, one neutron can be used to sustain the fission chain reaction and the excess neutrons can be used to create more fuel; (2) Some nonfissionable nuclei can be converted into fissionable nuclei by capture of a neutron of proper energy. Nonfissionable uranium-238, for example, can thus be bred into fissionable plutonium-239 in a nuclear reactor powered by plutonium.

boiling water reactor (BWR): a nuclear reactor in which water, used as both coolant and moderator, is allowed to boil in the reactor core. The resulting steam can be used directly to drive a turbine.

British Thermal Unit (BTU): the quantity of heat necessary to raise the temperature of one pound of water one degree Fahrenheit. One BTU equals 252 calories, gram (mean), 778 foot-pounds, 1055 joules and 0.293 watt-hours.

bus: an electrical conductor which serves as a common connection for two or more electrical circuits. A bus may be in the form of rigid bars, either circular or rectangular in cross section, or in form of stranded-conductor overhead cables held under tension.

busbar: an electrical conductor in the form of rigid bars, located in switchyard or power plants, serving as a common connection for two or more electrical circuits.

calorie: originally, the amount of heat energy required to raise the temperature of 1 gram of water 1 degree C. Because this quantity varies with the temperature of the water, the calorie has been redefined in terms of other energy units. One calorie is equal to 4.2 joules.

central station power: production of power -- usually electrical in large quantities at an industrial plant as opposed to production at the point of consumption.

coal: a solid, combustible organic material formed by the decomposition of vegetable material without free access to air. Chemically, coal is composed chiefly of condensed aromatic ring structures of high molecular weight. It thus has a higher ratio of carbon to hydrogen content than does petroleum.

coal gasification: the conversion of coal to a gas suitable for use as a fuel.

coal slurry pipelines: a pipeline which transports coal in pulverized form suspended in water.

conduction: the process by which energy is transferred directly from molecule to molecule. It is the way in which electricity travels through a wire or heat moves from a warm body to a cool one when the two bodies are placed in contact.

continental shelf: the submerged shelf of land sloping gradually from the exposed edge of a continent. It is usually defined as those areas where the water is less than 200 meters (600 feet) deep.

controlled thermonuclear reactor: controlled fusion, that is, fusion produced under research conditions, or for production of useful power.

convection: the transfer of heat by the circulation of a liquid or gas.

converter reactor: a nuclear reactor that produces some fissionable materials from uranium-238 or thorium, but less than the nuclear material it consumes. Light water reactors and high temperature gas cooled reactors are converters.

cooling pond: an artificial pond used to receive and dissipate waste heat, usually from a steam-electric power plant. Approximately an acre of pond surface is needed per megawatt of electric output for a modern steam-electric power plant.

core: the central part of a nuclear reactor which contains the nuclear fuel.

cracking: the process of producing low molecular weight hydrocarbons from heavier hydrocarbons by heating with or without catalysts. If the reaction is performed in the presence of excess hydrogen, it is called hydrocracking. Both processes are widely used for the production of volatile fuels such as gasoline.

critical mass: the minimum amount of a fissionable material, such as uranium-235 or plutonium-239, that is required to sustain fission in a nuclear reactor.

crude oil: petroleum liquids as they come from the ground. Also called simply "crude".

curie: the unit of radioactivity. One curie is the amount of a radioactive isotope necessary to produce 3.7×10^{10} disintegrations per second. One gram of radium has 1 curie radioactivity.

decay, radioactive: the process whereby atoms of radioactive substances experience transformation into atoms of other elements with attendant emission of penetrating radiations (gamma ray) and some nuclear particles. Each radioactive substance has a unique decay rate which may range from a fraction of a second to hundreds of years or more.

degree day, cooling: a measure of the need for air conditioning (cooling based on temperature and humidity), although cooling degree days are published for many weather stations, specific procedure has not been generally accepted.

degree day, heating: a measure of the coldness of the weather experienced, based on the extent to which the daily mean temperature falls below a reference temperature, usually 65 degrees F.

demand: the rate at which electric energy is delivered to or by a system or to a piece of equipment expressed in kilowatts, kilovolt-amperes, or other suitable unit at a given instant or averaged over any designated period of time. See load.

depletion allowance: a tax allowance extended to the owner of exhaustible resources based on an estimate of the permanent reduction in value caused by the removal of the resource.

deuterium: a nonradioactive isotope of hydrogen whose nucleus contains one neutron and one proton and is therefore about twice as heavy as normal hydrogen. Often referred to as heavy hydrogen.

diesel oil: the oil left after petroleum and kerosene have been distilled from crude oil.

direct current (dc): an electric current, such as that produced by a battery, in which the electrical potential does not change its sign, so that the voltage is essentially invariant with time. In a direct current, therefore, energy is carried by a continuous, undirectional flow of electrons through a conductor.

doubling time: in the long-term (multi-cycle) operation of a breeder reactor system, the time required to achieve a net doubling of the inventory of fissionable material present in the system, expressed in years. Doubling time depends on the breeding gain and the specific power at which the reactor operates.

electrical energy: the energy associated with electric charges and their movements. Measured in watt hours or kilowatt hours. One watt-hour equals 860 calories.

electron: an elementary particle with a rest mass of 9.1×10^{-28} grams, bearing either a positive or negative electric charge. Negative electrons orbit the atomic nucleus; their transfer or rearrangement between atoms underlies all chemical reactions. Either negative or positive electrons (sometimes

called positrons) may be emitted from atomic nuclei during nuclear reactions; they are then called beta particles and they are the constituents of beta rays.

energy: the capacity to produce heat or do work. A quantity which is conserved, although it may be exchanged among bodies and transformed from one form to another, converted between heat and water, or interconverted with mass.

energy conversion: the transformation of energy from one form to another.

enrichment: the process of increasing the concentration of fissionable uranium-235 in uranium from the naturally occurring level of about 0.7 percent to the concentration required to sustain fission in a nuclear reactor, generally about three percent. The principal method of enrichment is gaseous diffusion, but gaseous centrifugation is also receiving much attention, particularly abroad.

environmental impact statements: the analytical statements that balance costs and benefits of a Federal decision. Required by the National Environmental Policy Act, sec. 102(2)(c).

EPA (Environmental Protection Agency): a Federal agency created in 1970 to permit coordinated and effective governmental action for protection of the environment by the systematic abatement and control of pollution through integration of research, monitoring, standard setting and enforcement activities.

exponential growth: type of growth illustrated by the compound interest law. A useful characteristic of an exponential growth rate is that the "doubling time", or the length of time required for the growing thing to double in size, is constant.

fast breeder reactor: a fast nuclear reactor that operates with neutrons at the fast speed of their initial emission from the fission process, and that produces more fissionable material than it consumes.

fast neutron: high energy neutron. Fast neutrons are utilized in the fast breeder reactor both to produce nuclear fissions and to transform fertile material (e.g., ^{238}U into fissionable nuclear fuel.

fast reactor: a nuclear reactor in which the fission chain reaction is sustained primarily by fast neutrons. Fast reactors contain no moderator and inherently require enriched fuel. They are of interest because of favorable neutron economy which makes them suitable for breeding.

feedstock: fossil fuels used for their chemical properties, rather than their value as fuel, e.g., oil used to produce plastics and synthetic fabrics.

fertile material: a material, not itself fissionable by thermal neutrons, which can be converted into a fissionable material by irradiation in a nuclear reactor. The two basic fertile materials are uranium-238 and thorium-232.

fission: the splitting of a heavy nucleus into two approximately equal parts (which are radioactive nuclei of lighter elements), accompanied by the release of a relatively large amount of energy and generally one or more neutrons. Fission can occur spontaneously, but usually is caused by nuclear absorption of neutrons or other particles.

fissile material: any material fissionable by slow neutrons. The three basic ones are uranium-235, plutonium-239, and uranium-233.

fixation (of nitrogen): the conversion of atmospheric nitrogen to ammonia or other compounds that can be used by plants. Carbon dioxide is also "fixed" into carbohydrates by green plants.

fluidized bed: a reaction chamber in which finely divided solid reactants are suspended and maintained in a state of turbulent motion by a stream of gas or liquid from below. As a result, the reactants flow and mix freely, the entire surface area of the particles is exposed to the fluid for reaction, and a high rate of heat transfer is obtained.

fly ash: the fine, solid particles of noncombustible material residue carried from a bed of solid fuel by the gaseous products of combustion.

fossil fuel: any natural occurring fuel of an organic nature, such as coal, oil shale, natural gas, or crude oil. Fossil fuels are organically formed from living matter.

fuel: a substance used to produce heat energy, chemical energy by combustion or nuclear energy by nuclear fission.

fuel cell: a device for converting the energy released in a chemical reaction directly into electrical energy.

fuel cycle: the series of steps involved in supplying fuel for nuclear power reactors. It includes mining, refining of uranium, fabrication of fuel elements, their use in a nuclear reactor, chemical processing to recover remaining fissionable material, reenrichment of the fuel, ref rication into new fuel elements and waste storage. Fuel cycle is sometimes used to refer to a similar series of steps for fossil fuels.

fusion: the combining of atomic nuclei of very light elements by collision at high speed to form new and heavier elements, resulting in the release of energy.

gallon: a unit of measure. A U.S. gallon contains 231 cu. in., 0.133 cubic feet, or 3.785 liters. It is 0.83 times the imperial gallon. One U.S. gallon of water weighs 8.3 lb.

gamma rays: very energetic electromagnetic radiation released as a result of transition from one energy level of another within an atomic nucleus. Gamma rays are frequently emitted during nuclear reactions.

gas cooled fast breeder reactor (GCBR): a fast breeder reactor which is cooled by a gas, usually helium, under pressure.

gas, manufactured: a gas obtained by destructive distillation of coal, or by the thermal decomposition of oil, or by the reaction of steam passing through a bed of heated coal or coke. Examples are coal gases, coke oven gases, producer gas, blast furnace gas, blue (water) gas, carbureted water gas. BTU content varies widely.

gas, natural: a naturally occurring mixture of hydrocarbon. gases found in porous geologic formations beneath the earth's surface, often in association with petroleum. The principal constituent is methane.

gas turbine: an engine which converts chemical energy of liquid fuel into mechanical energy by combustion. Gases resulting are expanded through a turbine.

gaseous diffusion: the principal process for enrichment of uranium; that is, for increasing the concentration of fissionable uranium-235 in a mixture of uranium isotopes to the level required to sustain fission in a nuclear reactor.

gasification: in the most commonly used sense, gasification refers to the conversion of coal to a high-BTU synthetic natural gas under conditions of high temperatures and pressures; in a more general sense, conversion of coal into a usable gas.

gasoline: a petroleum fraction composed primarily of small branched chain, cyclic, and aromatic hydrocarbons.

generator: a machine which converts mechanical energy into electrical energy.

geopressured reservoir: a reservoir whose wellhead pressure is substantially greater than normal as a result of the pressure of the earth above it.

geothermal energy: the heat energy available in the rocks, hot water, and steam in the earth's subsurface.

geothermal steam: steam drawn from deep within the earth. There are about 90 known places in the continental United States where geothermal steam might be harnessed for power. These are in California, Idaho, Nevada, and Oregon.

greenhouse effect: the warming of the lower atmosphere and the surface of the earth due to the absorption and reradiation of infrared radiation by the carbon dioxide and water vapor in the atmosphere.

Gross National Product (GNP): the Nation's total national output of goods and services at current market prices.

half-life, radioactive: time required for a radioactive substance to lose 50 percent of its activity by decay. Each radionuclide has a unique half-life.

head, gross: the difference of elevation between the headwater surface above and the tailwater surface below a hydroelectric power plant, under specified conditions.

heat: a form of kinetic energy, whose effects are produced by the vibration, rotation, and general motions of molecules.

heat exchanger: any device that transfers heat from one fluid (liquid or gas) to another or to the environment.

heavy water: deuterium oxide; that is, water in which all hydrogen atoms have been replaced by deuterium.

heat pump: a refrigeration machine that is used for heating rather than cooling. Expanding refrigeration fluid removes heat from a large heat source; the fluid is then compressed, and the heat resulting from compression is discharged to a heat exchanger next to the surroundings to be heated.

heat sink: the medium or location to which waste heat is discharged.

high temperature gas cooled reactor (HTGR): a reactor fueled with blocks of graphite containing fissile and fertile material and cooled with helium. HTGR's are operated at a high temperature which permits conversion of heat to electricity with high efficiency.

hydraulic fracturing: a general term, for which there are numerous trade or service names, for the fracturing of rock in an oil or gas reservoir by pumping a fluid under high pressure into the well. The purpose is to produce artificial openings in the rock in order to increase permeability.

hydrocarbon: a compound containing only carbon and hydrogen. The fossil fuels are predominantly hydrocarbons, with varying amounts of organic compounds of sulfur, nitrogen, and oxygen, and some inorganic materials.

hydroelectric plant: an electric power plant in which energy of falling water is converted into electricity by turning a turbine generator.

infrared: the portion of the electromagnetic spectrum associated with phenomena of heat. Infrared means "below the red"; infrared radiation is less energetic than visible light, which occupies the adjacent portion of the spectrum.

ion: an electrically charged atom or group of atoms.

ionization: the addition of electrons to or removal of electrons from atoms or molecules.

isotope: one of the possible forms of a chemical element, differing from other forms in the number of neutrons in the nucleus. Isotopes of an element usually have the same chemical properties but slightly different physical properties as a result of their different atomic weights.

joule: a unit of energy or work which is equivalent to one watt per second or 0.737 foot-pounds.

kerosine: the petroleum fraction containing hydrocarbons that are slightly heavier than those found in gasoline and naphtha.

kilowatt (Kw): 1,000 watts. A unit of power equal to 1,000 watts, or to energy consumption at a rate of 1,000 joules per second. It is usually used for electrical power. An electric motor rated at one horsepower uses electrical energy at a rate of about 3/4 kilowatt.

kilowatt-hour (kWh): a unit of work of energy equal to that expended by one kilowatt in one hour. It is equivalent to 3.6 M joules.

kinetic energy: the energy of motion; the ability of an object to do work because of its motion.

light-water reactor (LWR): a nuclear reactor in which water is the primary coolant/moderator with slightly enriched uranium fuel. There are two commercial light-water reactor types -- the boiling water reactor (BWR) and the pressurized water reactor (PWR).

lignite: a low grade coal of a variety intermediate between peat and bituminous coal.

liquefaction (of coal): the conversion of coal into liquid hydrocarbons and related compounds by hydrogenation.

liquefied natural gas (LNG): natural gas that has been liquefied by cooling to about -140°C. In this form, it occupies a relatively small volume and can be transported economically by ocean tanker.

liquefied petroleum gas (LPG): a mixture of gaseous hydrocarbons, principally propane and butane, which can be liquefied under moderate pressure at normal temperatures.

liquid metal fast breeder (LMFBR): a nuclear breeder reactor cooled by molten sodium in which fission is caused by fast neutrons.

lithium: element No. 3 (symbol, Li; atomic weight 6.94). As found in nature, lithium consists of a mixture of two stable isotopes -- lithium-6 (7.5 percent) and lithium-7 (92.4 percent). Lithium-6 is of interest as a possible fuel or source thereof for the generation of power from a controlled thermonuclear reaction.

load: the amount of power needed to be delivered at a given point on an electric system.

load growth: the growth in energy and power demands by a utility's customers.

Lurgi Process: the chief commercially available process for coal gasification. Having originated in Germany, this process has limited application in the United States because of problems of scaling up the size of operations and characteristics of U.S. coal. The Office of Coal Research and American Gas Association are jointly funding further development.

LWR: light-water reactor.

margin: the difference between the net system generating capability and system maximum load requirements including net schedule transfers with other systems.

market penetration rate: the fraction of new and replacement market which is held by a particular process or product.

megawatt (MW): 1,000 kilowatts, 1 million watts.

metallurgical coal: coal with strong or moderately strong coking properties that contains no more than 8.0 percent ash and 1.25 percent sulfur, as mined or after conventional cleaning.

methane (CH_4): the lightest in the paraffinic series of hydrocarbons. It is colorless, odorless and flammable. It forms the major portion of marsh gas and natural gas.

middle distillate: one of the distillates obtained between kerosene and lubricating oil fractions in the refining processes. These include light fuel oils and diesel fuel.

mine-mouth plant: a steam-electric plant or coal gasification plant built close to a coal mine. It is usually associated with delivery of output via transmission lines or pipelines over long distances as contrasted with plants located nearer load centers and at some distance from sources of fuel supply.

moderator: a material, for example graphite or water, used to control the energy of neutrons in a nuclear reactor. By slowing down neutrons to speeds at which they tend not to be absorbed by nonfissionable nuclei, the moderator prevents quenching of the chain reaction, and permits the reactor to operate at low fuel enrichments.

National Environmental Policy Act (NEPA): an act passed in 1970 requiring that the environmental impact of most large projects and programs be considered. Among its important provisions is one requiring a detailed statement of environmental impact of and alternatives to a project to be submitted to the government before the project can begin.

natural gas: naturally occurring mixtures of hydrocarbon gases and vapors, the more important of which are methane, ethane, propane, butane, pentane, and hexane. The energy content of natural gas is usually taken as 1032 BTU/cu.ft.

natural uranium: uranium as found in nature, containing 0.7 percent uranium-235, 99.3 percent of uranium-238 and a trace of uranium-234. It is also called normal uranium.

net reserves: the recoverable quantity of an energy resonance that can be produced and delivered.

neutron: an elementary particle with approximately the mass of a proton but without any electric charge. It is one of the constituents of the atomic nucleus. It is frequently released during nuclear reactions and, on entering a nucleus, can cause nuclear reactions including nuclear fission.

nitrogen oxides (NOx): chemical compounds of nitrogen (N) and oxygen (O). A product of combustion of fossil fuels whose production increases with the temperature of the process. It can become an air pollutant if concentrations are excessive.

non-symbiotic nitrogen fixation: the fixation of nitrogen by free-living organisms in the soil or in water.

nuclear energy: energy released as particulate or electromagnetic radiation and heat during reactions of atomic nuclei.

nuclear fission: the splitting of large atomic nuclei into two or more new nuclear species, with the release of large amounts of energy.

nuclear fuel cycle: the various steps which involve the production, processing, use and reprocessing of nuclear fuels.

nuclear fusion: the process by which small atomic nuclei join together with the release of large amounts of energy.

nuclear power plant: any device, machine, or assembly that converts nuclear energy into some form of useful power, such as mechanical or electrical power.

nuclear reactor: a device in which a fission chain reaction can be initiated, maintained, and controlled. Its essential component is a core with fissionable fuel. It usually has a moderator, reflector, shielding, coolant and control mechanisms. It is the basic machine of nuclear power.

nucleon: a proton or neutron, one of the particles comprising the atomic nucleus.

oil shale: a sedimentary rock containing solid organic matter from which oil can be obtained when the rock is heated to a high temperature.

OPEC: Organization of Petroleum Exporting Countries. Founded in 1960 to unify and coordinate petroleum policies of the members. The members and the date of membership are: Abu Dhabi (1967); Algeria (1969); Indonesia (1962); Iran (1960); Iraq (1960); Kuwait (1960); Libya (1962); Nigeria (1971); Qatar (1961); Saudi Arabia (1960); and Venezuela (1960). OPEC headquarters is in Vienna, Austria.

outage: the period in which a generating unit, transmission line, or other facility, is out of service.

ozone: a form of molecular oxygen containing three atoms of oxygen per molecule. Ozone is deadly to life, but bands of ozone high in the atmosphere absorb lethal ultraviolet radiation and thus protect life on earth.

particulate matter: solid particles, such as the ash, which are released from combustion process in exhaust gases at fossil-fuel plants.

peaking capacity: that part of a system's equipment which is operated only during the hours of highest power demand.

peaking load: the greatest amount of all of the power loads on a system, or part thereof, which has occurred at one specified period of time.

petroleum: an oily flammable bituminous liquid that may vary from almost colorless to black, occurs in many places in the upper strata of the earth, is a complex mixture of hydrocarbons with small amounts of other substances, and is prepared for use as gasoline, naphtha, or other products by various refining processes.

petroleum refinery: a plant that converts crude petroleum into the many petroleum fractions (asphalt, fuel oil, gasoline, etc.). Usually this conversion is accomplished by fractional distillation.

photochemical reaction: a chemical reaction brought about by light; one which derives the necessary energy from light. See photosynthesis. Photochemical reactions play a major role in the formation of smog.

photon: a quantum of electromagnetic energy having properties of both a wave and a particle, but without mass or electric charge.

photosynthesis: a photochemical reaction by which carbon dioxide is reduced (fixed) to carbohydrate in the presence of chlorophyll. The process by which green plants utilize solar energy to convert carbon dioxide and water into new biomass.

plasma: an electrically neutral, partially ionized gas in which the motion of the constituent particles is dominated by electromagnetic interactions. The study of plasma motions is called magnetohydrodynamics (MHD).

plutonium (Pu): a heavy, fissionable, radioactive, metallic element with atomic number 94. Plutonium occurs in nature in trace amounts only. However, it can be produced as a by-product of the fission reaction in a uranium fueled nuclear reactor and can be recovered for future use.

pollution: the accumulation of wastes or by-products of human activity. Pollution occurs when wastes are discharged in excess of the rate at which they can be degraded, assimilated, or dispersed by natural processes. Sometimes noxious environmental effects not caused by human activity are also called pollution.

potential energy: energy which is not associated with motion -- thus that which is stored in chemical bonds and water at high elevations are forms of potential energy.

power: the rate at which work is done or energy is transferred. Power is measured in units of work per unit time; typical units are the horsepower and the watt.

pressurized-water reactor: a power reactor in which heat is transformed from the core to a heat exchanger by water kept under high pressure to prevent it from boiling. Steam is generated in a secondary circuit.

primary fuel: fuel consumed in original production of energy as contrasted to a conversion of energy from one form to another.

primary producers: organisms (green plants or certain bacteria) which produce organic compounds through photosynthesis or chemosynthesis.

proton: a positively charged elementary particle having a mass of about 1.7×10^{-24} grams, roughly 1840 times as great as the mass of an electron. Protons are constituents of atomic nuclei and are emitted in some nuclear reactions.

proved reserves: the estimated quantity of crude oil, natural gas, natural gas liquids or sulfur which analysis or geological and engineering data demonstrates with reasonable certainty to be recoverable from known oil or gas fields under existing economic and operating conditions.

pumped storage: an arrangement in which water is pumped into a storage reservoir when a surplus of electricity is being generated; during times of peak demand for electricity, this water is then used for the generation of electricity as in any hydroelectric power plant.

radiation: the process by which energy in the form of electromagnetic radiation is emitted from matter. Also, the electromagnetic or particulate rays that are emitted from atoms or molecules as they undergo internal change.

radioactivity: the spontaneous decomposition of an atom accompanied by the release of energy.

reactor: any device in which a chemical or nuclear reaction is sustained in a self-supporting chain.

refinery: an industrial complex for processing crude oil by destillation and chemical reactions so as to produce a separate petroleum product. Typical crude fractions, from top to bottom or simple to complex, are: ether, methane, and ethane, (the gasolines); propane, and butane; kerosene, fuel oil, and lubricants; jelly paraffin, asphalt, and tar.

reserves: the amount of a fuel or other mineral resource known to exist and expected to be recoverable by existing techniques and under existing economic conditions.

reserve generating capacity: extra capacity maintained to generate power in the event of unusually high demand or a loss or scheduled outage of regular generating capacity.

residual fuel oil: a high-viscosity fuel oil that must be heated before it can be pumped and handled conveniently. Residual fuel oil is the petroleum fraction that is collected after all lower-boiling fractions have been distilled away. It is used primarily in industry, in large commercial buildings, and for the generation of electricity.

secondary recovery: oil and gas obtained by the augmentation of reservoir energy; often by the injection of air, gas, or water into a production formation.

slow neutron: a low energy neutron, sometimes called a thermal neutron. The energy of a slow neutron is about 0.025 electron volts, in contrast to the energy of a fast neutron, which may exceed 1,000 electron volts. Slow neutrons are very efficient in causing fission of uranium-235. Nuclear power plants now in operation are designed to use slow neutrons to sustain the fission reaction.

smog: term used broadly to mean polluted air. There are various types of smog which are produced from certain classes of pollutants under specific meteorologic conditions. Photochemical smog results from photochemical reactions involving hydrocarbons and oxides of nigrogen, common constituents of polluted air. Term is derived from smoke and fog.

solar cell: a device which converts solar radiation to a current of electricity.

solar constant: the average intensity of solar radiation striking the atmosphere. The solar constant is measured on a plane perpendicular to the path of the radiation. Its value is 1.36 kilowatts per square meter.

solar furnace: an optical device with large mirrors that focuses the rays from the sun upon a small focal point to produce very high temperatures.

solar spectrum: the total distribution of electromagnetic radiation emitted from the sun, minus those wave lengths that are absorbed by the solar atmosphere.

stack gas desulfurization: treating of stack gases to remove sulfur compounds.

steam electric plant: a plant in which the prime movers (turbines) connected to the generators are driven by steam.

strip mining: the mining of coal by removing covering material (the overburden) and "stripping" away the entire underlying coal seam. Other forms of coal mining are underground, and auger mining in which coal is drilled out of seams exposed along the side of a mountain.

synthetic natural gas (SNG): a manufactured gaseous fuel generally produced from naphtha or coal. It contains 95 to 98 percent methane, and has an energy content of 980 to 1035 Btu per standard cubic foot, about the same as that of natural gas.

tar sands: sedimentary rocks which contain viscous, heavy petroleum that cannot be recovered by conventional methods of petroleum production.

tertiary recovery: use of heat and other methods other than fluid injection to augment oil recovery (presumably occurring after secondary recovery).

thermal pollution: an increase in the temperature of water resulting from waste heat released by a thermal electric plant to the cooling water when the effects on other uses of the water are detrimental.

thermal power plant: any electric power plant which operates by generating heat and converting the heat to electricity.

thermal reactor: a nuclear reactor in which the fission process is propagated mainly by thermal neutrons, i.e., by neutrons that have been slowed down until they are in thermal equilibrium with the atoms of the moderator.

thermionic device: a device which converts heat into electricity by "boiling" electrons from a hot metal surface and condensing them on a cooler surface.

thermodynamics, laws of: the first law of thermodynamics states that energy can neither be created nor destroyed. The second law of thermodynamics states that when a free exchange of heat takes place between two bodies, the heat is always transferred from the warmer to the cooler body.

thorium (Th): a naturally radioactive element with atomic number 90 and, as found in nature, an atomic weight of approximately 232. The fertile thorium-232 isotope is abundant and can be transmuted to fissionable uranium-233 by neutron irradiation. (A naturally radioactive metal. One of its natural isotopes can be converted in nuclear reactors to a nuclear fuel.)

ton: a unit of weight equal to 2,000 pounds in the United States, Canada and the Union of South Africa, and to 2,240 pounds in Great Britain. The American ton is often called the short ton, while the British ton is called the long ton (tonne). The metric ton, or 1,000 kilograms, equals 2,204.62 pounds. Depending upon specific gravity, a long ton or metric ton will equal from 6.5 to 8.5 barrels of oil.

tritium (T): a man-made radioactive isotope of hydrogen with two neutrons and one proton in the nucleus.

turbine: a motor, the shaft of which is rotated by a stream of water, steam, air, or fluid from a nozzle and forced against blades of a wheel.

ultraviolet: the portion of the electromagnetic spectrum lying between the range of visible light and X-rays.

unit train: a system developed for delivering coal more efficiently in which a string of cars, with distinctive markings, and loaded to "full visible capacity," is operated without service frills or stops along the way for cars to be cut in and out. In this way, the customer receives his coal quickly and the empty car is scheduled back to the coal fields as fast as it came.

uranium (U): a radioactive element with the atomic number 92 and, as found in natural ores, an average atomic weight of approximately 238. The two principal natural isotopes are uranium-235 (0.7 percent of natural uranium) which is fissionable (capable of being split and thereby releasing energy) and uranium-238 (99.3 percent of natural uranium) which is fertile (having the property of being convertible to a fissionable material). Natural uranium also includes a minute amount of uranium-234.

vertical integration: the control by one company of the various stages of a commodity from primary production, through processing and marketing, to final consumers.

waste heat: heat which is not economically valuable for production of power and therefore must be discharged to the environment.

wastes, radioactive: equipment and materials, from nuclear operations, which are radioactive and for which there is no further use. Wastes are generally classified as high-level (having radioactivity concentrations of hundreds to thousands of curies per gallon or cubic foot), low level (in the range of 1 microcurie per gallon or cubic foot), or intermediate.

watt: a unit of power. It is the rate of energy use or conversion when one joule of energy is used or converted per second. (A joule is about 0.25 calories.)

watt-hour: the total amount of energy used in one hour by a device that uses one watt of power for continuous operation. Electrical energy is commonly sold by the kilowatt hour (1,000 watt-hours).

well head: oil or gas brought to the surface, ready for transportation to refinery or ship or pipeline. Well head costs usually refer to the cost to bring the oil or gas to the surface and do not include costs of transportation, refining, distribution, or profit.

work: the transfer of energy from one body to another; or the energy itself, in the process of transfer. Work and energy are measured in the same units.

X-rays: very energetic electromagnetic radiation. Their emission is commonly associated with changes in energy levels of electrons near the atomic nucleus.